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AIR FORCE HUMAN RESOURCES LABORATORY

(2) LEVEL II

LOGIC TREE TROUBLESHOOTING AIDS: ORGANIZATIONAL AND INTERMEDIATE MAINTENANCE

By

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Final Report

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides a draft military specification for use in the procurement of Logic Tree Troubleshooting Aids (LTTAs). Recent research has demonstrated that the use of LTTAs can significantly improve the efficiency and effectiveness of maintenance personnel in performing troubleshooting tasks. The use of LTTAs results in quicker location of faults and reduced consumption of spare parts. However, at present there is no specification available for the procurement of LTTAs. The draft specification was developed to fill this need.

A thorough review of the state of the art in preparing and using LTTAs was made to provide the basis for developing the draft specification. This was accomplished by reviewing available literature and then conducting extensive interviews with government and industry personnel with experience in developing, using and evaluating

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LTTAs. The results of the interviews were analyzed to provide the basis for establishing the requirements for developing LTTAs. The goal was to develop a specification which establishes basic requirements for developing LTTAs which will result in improved performance while still providing enough flexibility to be suitable for application to a wide variety of applications.

The draft specification provides specific and general requirements for the development of LTTAs. These include requirements for (a) task analysis, (b) development of troubleshooting procedures, (c) development of checkout procedures, (d) presentation formats, (e) preliminary information, (f) supplemental and support information (wiring diagrams, theory of operation, etc.), (g) varying levels of enrichment, and (h) dual level presentation. The specification is suitable for use in procuring LTTAs for use with all types of equipment: electrical, electronic, mechanical, pneumatic, hydraulic, optical and combinations thereof. It is suitable for procurement of LTTAs for use at the intermediate and organizational levels of maintenance. The specification may also be used for the development of checkout and logic tree procedures for use in other types of manuals.

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PREFACE

This draft, dated November 1979, prepared by Management and Technical Services Company (MATSCO), as agent of Air Force Human Resources Laboratory, has not been approved and is subject to modification. Contract No. F33615-78-C-0015.

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DRAFT MILITARY SPECIFICATION FOR

MANUALS, TECHNICAL: LOGIC TREE TROUBLESHOOTING AID

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification defines the requirements for the content and format of a Logic Tree Troubleshooting Aid (LTTA) type of technical manual to support the troubleshooting requirements of personnel at Organizational and Intermediate maintenance levels. A secondary use of this specification is for the preparation of Checkout procedures and Logic Tree troubleshooting procedures for use in other types of manuals. As used in this specification, a "Logic Tree" is a branching-tree representation of a decision-making process. It depicts the logical and orderly step-by-step process a technician will follow to isolate malfunctions to a repairable or replaceable unit. Similarly, a "Checkout" is an orderly procedure for checking all measurable outputs for a system to determine if it is functioning properly.

1.2 Application. This specification applies to all classes of equipment: electrical, electronic, mechanical, pneumatic, hydraulic, optical, and combinations thereof. This specification applies to all types of activities, systems, and equipments including those in which the maintenance concept terminology differs somewhat from terms used herein. For example, this specification is equally appropriate for systems in which maintenance activities are categorized as "on-equipment" and "off-equipment," as delineated in Production Oriented Maintenance Organization (AFR 66-5), and Equipment Maintenance Policies, Objectives, and Responsibilities (AFR 66-14).

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on the date of the invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-M-38784	Manuals, Technical: General Style and Format Requirements
MIL-P-38790	Printing Production of Technical Manuals: General Requirements for
MIL-M-38800 (USAF)	Manuals, Technical: Organizational Maintenance Instructions
MIL-M-83495 (USAF)	Manuals, Technical, Organizational Maintenance Manual Set: General Requirements for Preparation of
AFHRL-TR-79-50	Maintenance Task Identification and Analysis
MIL-I-45208	Inspection System Requirements
MIL-Q-9858	Quality Program Requirements

STANDARDS

MIL-STD-863	Preparation of Wiring Diagrams and System Schematic Diagrams
MIL-STD-1388-1 & -2	Logistic Support Analysis

(Copies of the above documents may be obtained from the Commanding Officer, *Naval Publications and Forms Center*, 5801 Tabor Avenue, Philadelphia, PA 19120.)

3. REQUIREMENTS

3.1 General requirements. This section defines the requirements for LTTA development and preparation and delivery. The development of a LTTA and the strategy within each troubleshooting aid is based on a careful Maintenance Task Identification and Analysis (MTI&A) for the applicable equipment or system and User needs.

3.1.1 Maintenance task identification and analysis. The first step in planning and preparing the LTTA is MTI&A, also referred to as task analysis. This process defines the specific faults and fault symptoms to be considered when organizing the LTTA. Development of the LTTA requires a systematic study of the system to identify troubleshooting tasks and determine the scope, method of performance, and other important details of troubleshooting. MTI&A provides this systematic process of data collection, analysis, and decision making by answering questions such as: What Checkout and Troubleshooting tasks are required? Which should be included in the LTTA and at what maintenance level? What are the preconditions? What support equipment is needed? At what level of detail should LTTA procedures be written to accommodate the User? What support equipment will be available? On many systems, the task analysis effort will be a formal part of the contract requirements because AFHRL-TR-79-50 will be invoked. If it is not invoked, a comparable but less formal troubleshooting task analysis shall be implemented to ensure a complete, accurate, and understandable LTTA.

3.1.2 LTTA organization and content

3.1.2.1 Minimum content. The organization and content of the LTTA may vary depending on many factors such as system application, maintenance concept, level of enrichment, training, staffing, and funding. However, the minimum LTTA shall include:

a. Front Matter

b. Introduction

c. Preparation for Checkout (instructions)

d. Checkout

e. Preparation for Troubleshooting (instructions)

f. Logic Trees

g. Locator diagrams

h. Documents as specified by SOW

3.1.2.2 Optional aids. If specified in the contract Statement of Work, the LTTA shall be expanded to include the optional aids listed below:

a. Supporting Aids

(1) Functional block diagrams (see 3.5.1)

(2) Schematic diagrams (see 3.5.2)

(3) Troubleshooting strategies (see 3.5.3)

b. Appendices (if needed for supporting data)

3.1.3 Relationship to other manuals. Logic Tree Troubleshooting Aid manuals prepared for Organizational and Intermediate maintenance levels shall interface with other manuals as described in the next two paragraphs.

3.1.3.1 Manual set for Organizational maintenance. A LTTA is normally procured as part of an Organizational maintenance manual set in accordance with MIL-M-83495. Data and procedures in the LTTA shall therefore complement the system descriptions, theory of operation, test, remove and replace, repair, wiring diagram, and other types of maintenance information contained in the General Vehicle (GV), General Systems (GS), Job Guide (JG), Wiring Data (WD), Schematic Diagram (SD), Fault Reporting (FR), and Fault Isolation (FI) manuals. If the LTTA is developed in conjunction with the Fault Reporting manual to replace the Fault Isolation manual, the troubleshooting aids in the LTTA shall resolve the faults and fault symptoms reported by the operating crew as well as those derived from Checkout procedures. If the LTTA manual is prepared in lieu of the FR and FI manuals, it shall contain all system troubleshooting procedures.

3.1.3.2 Manual set for Intermediate maintenance. When the LTTA is procured for Intermediate maintenance, it shall be developed to complement the technical data in the other manuals of the set. All data included in the Intermediate manual set shall facilitate fault isolation and repair within the assemblies, subassemblies, sub-subassemblies, and components designated for repair by an Intermediate maintenance facility. The title and general content of each manual in the set shall be as follows:

a. Description and Theory of Operation (DTO) manual. This manual provides description, theory of operation, functional block diagrams, and closely related information.

b. Logic Tree Troubleshooting Aid (LTTA) manual. This manual shall provide Checkout, fault isolation, and closely related information as specified in this specification.

c. Intermediate Job Guide (IJG) manual. This manual provides disassembly, cleaning, evaluation inspection, repair/parts replacement, lubrication, final inspection, test, assembly, and closely related information.

d. Intermediate Schematic Diagram (ISD) manual. This manual provides schematic diagrams for assemblies, subassemblies, and subsubassemblies. Subsystem schematic diagrams not provided in the Organizational Schematic Diagram manual may also be included when such need is identified by the Task Identification and Analysis.

e. Intermediate Wiring Data (IWD) manual. This manual provides wiring data and diagrams for assemblies, subassemblies, and subsubassemblies. Subsystem wiring data not provided in the Organizational Wiring Data manual may also be included when such need is identified by the Task Identification and Analysis.

3.1.4 General format requirements. LTTA manuals shall be prepared in accordance with MIL-M-38784 and MIL-P-38790 except for format, presentation, and technical content, which shall be as specified herein. Also, technical content shall be compatible with other technical manuals prepared in accordance with MIL-M-38800 and MIL-M-83495 for the same equipment or system. Except as specified in the contract Statement of Work, the requirements of this specification shall have precedence over other specifications.

3.1.4.1 Volumes. A LTTA shall be organized into a volume(s) in accordance with the following requirements, and that determination shall be included in the Publication/QA plan required by 3.1.6.

a. The structure of the volume(s) shall be based upon an analysis of system characteristics, subsystem interrelationships, test or support equipment availability, maintenance levels, and maintenance concept.

b. The LTTA shall be organized into sections or chapters in the most practical sequence.

c. For smaller systems or subsystems, two or more sets of troubleshooting aids may be included in one volume, with Government approval. Such volumes shall be divided into chapters. Chapter 1 shall contain an overall Introduction and each of the other chapters shall provide a complete and self-contained set of preparation instructions, troubleshooting aids, and supporting aids for one of the systems, subsystems, or equipments.

d. A large system shall be covered in one or more volumes. If a one-volume LTTA is planned, all of the elements in 3.1.2.1 will be included in this volume. If more than one volume is needed, LTTA elements shall be separated only at logical points (e.g., a separate volume for Checkout, one or more for Logic Trees, and a separate one for Supporting Aids).

3.1.4.1.1 LTTA for Organizational maintenance. An Organizational level LTTA shall consist of one or more volumes in accordance with 3.1.4.1. Each volume shall be developed in accordance with the following parameters:

a. Each volume shall be pocket size (4" x 8") or standard manual page size (8-1/4" x 10-3/4") as specified by the contract Statement of Work, or as determined by the troubleshooting task analysis and User needs.

b. Pocket sized volumes shall be no more than 70 sheets (140 pages if printed both sides).

3.1.4.1.2 LTTA for Intermediate maintenance. An Intermediate level LTTA shall be one or more volumes in accordance with 3.1.4.1. Each volume shall be standard page size (8-1/4" x 10-3/4") and shall be less than 300 pages printed on both sides.

3.1.4.1.3 System/Subsystem/Subject Numbering (S/S/SN). In Organizational or Intermediate LTTAs, an applicable S/S/SN number shall be placed on each page in accordance with MIL-M-83495. These numbers shall be used as a subject matter key to cross reference and locate related and similar items of information between the various volumes of the maintenance manual set — particularly between the Fault Reporting (FR) manual, Fault Isolation (FI) manual, and the Logic Tree Troubleshooting Aid (LTTA) manual.

3.1.4.2 Front matter

3.1.4.2.1 General items. The front matter for each volume shall contain the following items in accordance with MIL-M-38784:

a. Title Page
b. Warning Page
c. List of Effective Pages
d. Promulgation Pages
e. Change Record
f. Table of Contents
g. Safety Summary

3.1.4.2.2 Specialized lists. The front matter for each volume shall also contain the following lists, prepared in accordance with the referenced paragraphs:

a. List of Illustrations (see 3.1.4.2.3)

b. List of Tables (see 3.1.4.2.4)

c. List of Checkouts (see 3.2.5)

d. List of Logic Trees (see 3.3.8)

3.1.4.2.3 List of illustrations. Each volume shall contain a list of illustrations in that volume, including charts and graphs assigned figure or foldout numbers. If more than one volume is required for a system, the first volume in the set shall also contain a list for each of the other volumes. Each such listing shall be in single-column format (full page width) and show the following information for each line entry:

a. Figure or foldout number. For each section or chapter, the listing of figures shall precede the listing of foldouts.

b. Title of figure or foldout (see 3.4)

c. Page number for each figure and foldout

3.1.4.2.4 List of tables. Each volume shall contain a list of the tables in that volume. If more than one volume is required for a system, the first volume in the set shall also contain a list of tables for the other volumes. Each such listing shall be in single-column format (full page width) and show the following information for each line entry:

a. Table Number

b. Title of Table

c. Page Number of Table

3.1.4.2.5 Pagination. All pages of front matter shall be numbered in the bottom center, using lower case Roman numerals in the form: i, ii, etc.

3.1.4.2.6 Technical manual identification. All pages of front matter except the title page shall show the assigned Technical Manual number in the upper right-hand corner of odd-numbered pages, and the upper left-hand corner of even-numbered pages.

3.1.4.3 "How To Use This Manual" section. An introductory section (or chapter) titled, "How To Use This Manual" shall be provided in each volume of the LTTA. Information of the following types shall be included:

a. Description and objectives of the volume

b. Description and objectives of each troubleshooting aid

c. When and how to use each troubleshooting aid

d. How the volume correlates with other volumes in the volume set

e. How the LTTA correlates with other manuals in the manual set

f. Other items essential to success of the trouble isolation process at applicable maintenance level.

3.1.4.4 Text pagination. Except as required elsewhere in this specification (3.2.2.11 and 3.3.2.9), pages shall be numbered in accordance with MIL-M-38784 (e.g., consecutively throughout the book).

3.1.5 Writing requirements

3.1.5.1 Writing styles. Various styles of writing shall be used in each manual depending on the level of enrichment (see 3.3.6) and the following:

a. Instructions to troubleshooters shall be second person imperative.

EXAMPLES:

(1) Set power switch to ON.

(2) Using snap ring pliers, remove retainer clip (7).

b. Questions to troubleshooters shall be third person interrogative.

EXAMPLES:

(1) Did signal flag change to green?

(2) Is circuit open between pins 2 and 8 of P49?

c. Notes, Cautions, and Warnings shall be second person imperative and third person indicative as required to best present the necessary information.

EXAMPLES:

(1) Do not open spoiler door when red CAUTION light is on.

(2) Do not touch metal tools to TP55. Transistor VR31 may be overloaded and damaged.

3.1.5.2 Syntax. Sentence elements shall be arranged in one of the following orders, depending on the use for the sentence:

a. Verb, subject, and object, predicate object, or indirect object

b. Subject, verb, and object, predicate object, or indirect object

c. If a qualifying phrase is required, it shall be placed first in the sentence. (The phrase shall begin with If, When, For, On, etc., to show that qualifying conditions exist.)

3.1.5.3 Verbs. Verbs shall be selected from the Verb List in Appendix B of this specification. If additional verbs are required to serve the unique needs of the system involved, a listing shall be prepared and submitted to the Procurement Agency for approval. If this list becomes known early enough, it shall be submitted with the Publication/QA plan required by 3.1.6.

3.1.5.4 Subjects. For second person imperative statements (as in Cautions, Warnings, and instructions) the subject, that is, "you," shall only be implied.

EXAMPLE:

Rotate handle clockwise to its stop.

3.1.5.5 Adverbs/adverbial phrases. Adverbs and adverbial phrases shall be used only in special cases where they are necessary to define the location of an item to be manipulated or to define a method or direction of manipulation.

EXAMPLES:

(1) Is control valve (8) fully open?

(2) On IFF control console, set NORM switch to OFF.

(3) Using nonmagnetic adjustment tool, rotate potentiometer fully clockwise.

3.1.5.6 Articles. Do not use articles except as required to ensure clarity of meaning.

3.1.5.7 Cautions. A Caution shall alert the User to procedures, practices, etc., which, if not strictly observed, could result in damage to, or destruction of equipment and the possibility of personal injury. Each Caution shall be

placed in the action flow path just ahead of the steps to which they apply. The word CAUTION shall be in bold face type, centered above the text, and underscored.

3.1.5.8 Warnings. A Warning shall alert the User to procedures, practices, etc., which, if not correctly followed, could result in personal injury or loss of life. Each Warning shall be placed in the action flow path just ahead of the steps to which they apply. The word Warning shall be centered above the text in bold face letters and underscored with a bold wavy line as shown in Figures 6 and 7.

3.1.5.9 References to diagrams. References to locator diagrams (i.e., foldouts) and the applicable items on those diagrams shall be provided in Checkouts and Logic Trees. These references shall be provided at appropriate points as necessary to guide the troubleshooter to illustrated data required to perform the Check or step in which the troubleshooter is involved. The style and placement of these references shall be as shown in the samples, Figures 1 and 6. If full enrichment of Logic Trees is specified (3.3.6.3), references to locator diagrams are not required.

3.1.5.10 Personnel requirements. The number of persons required to perform procedures shall be indicated only when required to ensure clarity of meaning or if unusual requirements exist.

3.1.5.11 Gender. All references to gender shall be in asexual terminology. For example, do not refer to the technician as "he" or "she," or to "his" or "hers," or to "Man A" and "Man B." Instead, use "Person A," "Person B," or repeat the subject noun (i.e., "troubleshooter," "operator," etc.)

3.1.5.12 Ranges and tolerances. Allowable values for ranges and tolerances shall be included at applicable points to define how the equipment or system must respond, either in numerical or quantitative terms, for it to be considered normal or "in tolerance." The following rules shall apply:

a. All voltage readings, resistance values, clearances, torque values, flow rates, pressures, motions, and other limiting conditions shall be provided at each place required for a successful troubleshooting decision. Values or quantities shall be specified in terms of the authorized tool or test equipment to be used for the specified test or check. Minimum and maximum values shall be shown as follows:

(1) Is voltage 20 (±4) Vdc?

(2) Is frequency observed as 680 (±2) kHz?

(3) Is resistance 15 (±3) ohms?

(4) Rotate crank 90 (±5) degrees clockwise.

(5) Is lever 0.35 (±.05) inch from limit stop?

(6) Does gauge read 3300 (±100) psi?

b. Realistic, measurable tolerances shall be called out as follows:

(1) Specified ranges shall be within the accuracy and calibration capabilities of authorized test equipment. Very small ranges shall not be specified when test equipment does not have the capability to measure such close tolerances.

(2) Ranges shall be as broad as practicable to avoid measurement or calibration limitations.

c. If not previously documented as a result of an engineering test program, value ranges and tolerances shall be determined by operating the system and exercising the variables of each output through their designed maximum and minimum limits or normal operation until the associated fault symptom is identified.

3.1.6 Publication/Quality Assurance plan

3.1.6.1 Plan content. The contractor shall develop and prepare a Publication/Quality Assurance plan describing planned provisions for preparing the LTTA. This plan shall be based on a document development analysis that considers all of the elements specified in 3.1.6.1 through 3.1.6.9. It shall be delivered to the contracting agency when specified by the contract Statement of Work. The contracting agency will review the plan and return approval or requirements for further improvement. The task analysis process shall begin as stipulated in the contract Statement of Work or, if not stipulated, it shall begin early enough in the LTTA development schedule to ensure that contract delivery schedules are met. As a minimum, the Publication/QA plan shall include a section for each of the following topics:

a. Introduction (see 3.1.6.2)

b. Structure of volumes (see 3.1.6.3)

c. Outline of volume content (see 3.1.6.4)

d. Task analysis procedures (see 3.1.6.5)

e. In-process reviews (see 3.1.6.6)

f. Validation procedures (see 3.1.6.7)

g. Verification procedures (see 3.1.6.8)

h. Milestones/progress chart (see 3.1.6.9)

i. Special verbs listing (see 3.1.5.3)

j. Quality Assurance plan (see 4.)

3.1.6.2 Introduction. The Introduction shall contain the objectives of the contractor, the purpose of Publication/QA plan, statement of compliance with contract and specification requirements, the problem items requiring Contractor and Government resolution, and items requiring action by the Government.

3.1.6.3 Structure of volumes. The Publication/QA plan shall include an outline for structuring the LTTA manual into one or more volumes, depending on the size and nature of the system or equipment under contract (see 3.1.4.1).

3.1.6.4 Volume content. The Publication/QA plan shall include a brief but comprehensive outline of the information to be included in each volume (see 3.1.2).

3.1.6.5 Task analysis procedures. The Publication/QA plan shall include a brief description of the task analysis data and procedures the contractor will use to ensure a complete and accurate LTTA manual. The following items shall be included:

a. Title, description, and schedule for each phase of analysis required by 3.1.1. These items shall be reflected in the milestone/progress chart required by 3.1.6.9.

b. Any unique features and benefits to be provided by the contractor.

3.1.6.6 In-process reviews. The Publication/QA plan shall include a description of:

a. The contractor's plan for performing continuous in-process reviews as required in 4.4. Methods for making best use of the contractor's Quality Assurance staff shall be well developed.

b. The contractor's provisions for facilitating in-process reviews to be conducted by the Government in accordance with 4.3.

3.1.6.7 Validation procedures. The Publication/QA plan shall include a schedule and description for Validation procedures to be conducted by the contractor in accordance with 4.6. The Validation schedule shall be reflected in the milestone/progress chart required by 3.1.6.9.

3.1.6.8 Verification procedures. The Publication/QA plan shall include a proposed schedule and a description of the contractor's provisions for facilitating the Verification process to be conducted by the Government in accordance with 4.7. The proposed schedule shall be reflected in the milestone/progress chart required by 3.1.6.9.

3.1.6.9 Milestone/progress chart. The Publication/QA plan shall include a milestone/progress chart for each Organizational or Intermediate LTTA manual required by the contract. Each chart shall show the key steps and phases in the respective development and preparation process. The times shall be shown at which each step will be completed, and each phase started and completed. The time frames for in-process reviews shall also be shown. Open-face progress bars and milestone symbols shall be used to construct the original chart. As work is completed the bars and symbols shall be filled in. A copy of the updated chart shall be available for each in-process review and as required by the Government.

3.2 Checkout requirements. The LTTA manual shall contain a Checkout section containing all of the Checkouts required for checking the system. A Checkout is an orderly sequence of all task steps needed to examine, check, or test all active measurable inputs and outputs of a designated system or subsystem to determine whether or not it is within tolerance. The purpose of a Checkout is to:

a. Identify and describe how to check significant measurable inputs and outputs of a system, subsystem, or equipment.

b. Systematically manipulate the hardware item under test and perform measurements that permit detection of any fault symptoms that might be present.

c. Direct the technician to the appropriate action required for trouble-shooting if a fault symptom is detected.

d. Determine that the system is completely operational after the symptom causing fault has been identified and corrected.

3.2.1 Planning requirements

3.2.1.1 Checkout with formal MTI&A. When a task analysis has been performed in accordance with AFHRL-TR-79-50, a Checkout shall be prepared to include each hardware item with a Checkout requirement identified by a task entry in the Task Identification Matrix, using task details provided by the Troubleshooting task analysis. The following task analysis documents shall be used as guides to aid in developing an accurate and complete set of task steps for the Checkout:

a. Task Identification Matrix (or Top-Down Breakdown)

b. Definitized User Profile

c. Level of Detail Guide

d. Support Equipment Guide

e. Performance Analysis, including list of Malfunction Symptoms and Failure Modes

3.2.1.2 Checkout without formal MTI&A. When AFHRL-TR-79-50 is not invoked, a Checkout shall be prepared to include each Checkout requirement identified in the task analysis breakdown. The contractor shall do a critical, searching analysis to identify the task steps required for a complete and accurate Checkout as specified herein. These task steps shall provide for procedural instructions, testing of active inputs and outputs, and troubleshooting or corrective action to return all outputs to normal in the event any input or output is found to be out of tolerance.

3.2.2 Format requirements. Checkouts shall be prepared in a specialized format in accordance with the following requirements.

3.2.2.1 Checkout title. Each Checkout shall begin with and be identified by a descriptive title in bold capital letters at the top of the image area, flush with the left margin. The title will be repeated in the same position on every page of the Checkout. The elements of this title shall be developed as follows:

a. The title shall begin with the word CHECKOUT and be numbered by section and sequence in the form: CHECKOUT 5-1, CHECKOUT 5-2, etc. (See item 1 in Figure 1.)

b. The second element shall be system or subsystem identification such as: APN-426 NAVIGATION SYSTEM. (See item 2 in Figure 1.)

c. The third element shall be a short phrase identifying the type of Checkout, such as: FLIGHT LINE CHECKOUT. (See item 3 in Figure 1.)

d. Each page of a Checkout shall be identified with sheet numbers: (Sheet 1 of 1), (Sheet 1 of 3), (Sheet 2 of 3), etc. (See item 4 in Figure 1.)

3.2.2.2 Checkout preface. Each Checkout shall begin with a brief, untitled preface that provides useful reference data not already described in the "Preparation for Checkout" instructions required by 3.2.4. (See item 5 in Figure 1.) The preface shall include:

a. A secondary usage of the Checkout when such information is not indicated by the Checkout title (see application in Figure 2)

b. Reference to applicable Startup and Shutdown procedures when these items are not to be included in the Checkout (see 3.2.2.3 b and 3.2.2.9)

c. Reference to supporting diagrams other than the locator diagram (if needed)

d. Notes and data necessary to successful completion of the Checkout (if any)

e. Estimated time to complete the Checkout

f. Minimum personnel required (if needed)

3.2.2.3 Check title. The elements of this title shall be as follows:

a. Each Check within the Checkout (see 3.2.3) shall be identified by a descriptive title in underscored capital letters. This title shall begin at the left margin, with its elements developed as follows:

(1) The complete series of titles shall be prefixed by the letters A, B, C, etc., in sequence (see items marked 6 in Figure 1.)

(2) Each title shall consist of the word CHECK and a brief phrase identifying the applicable section of the system.

b. When the task analysis indicates there is a probability that abnormal indications and fault symptoms will sometimes be identified while activating or starting the system, Check A of the Checkout shall be a STARTUP CHECK. (See application in Figure 3.) In other cases, the preface shall contain a reference to the applicable Startup procedure, or a brief procedure shall be provided. (See Figure 2.)

3.2.2.4 Check format. The steps within each Check shall be formatted in two columns. The left column shall be as wide as practicable and the right column shall be as narrow as practicable to make best utilization of the image area on the page. The left column shall contain the steps within each Check as specified in 3.2.2.5, and the right column shall contain a corrective action statement as specified in 3.2.2.6.

3.2.2.5 Steps column. The steps in the left column of a Check shall be formatted as follows:

a. The first line of each step shall be a brief description of the task to be done. Each such line shall be identified by the sequence numbers 1, 2, 3, etc., indented about 1 pica from the left margin. The description shall begin with the word CHECK and be in capital letters. (See item 7 in Figure 1.)

b. The detailed procedures in each step shall be identified by sequential lower case letters a, b, c, etc., indented about 2 picas. Subordinate substeps shall be identified by the sequential numbers in parentheses (1), (2), (3), etc., and indented 1 additional pica. (See item 8 in Figure 1.)

c. The first element of the detailed procedures shall be a reference to the applicable locator diagram in the form: "(See F/O X-X.)" (See item 9 in Figure 1.) The second element shall be location and identification information for the item(s) to be manipulated. (See item 10 in Figure 1.)

d. The third element shall be instructions for setting up the test and measurement to be made. When two or more subordinate actions are required, they shall be detailed separately as shown by substeps (1) and (2) (see item 11 in Figure 1.) However, if only one action is required it may be combined with the location/identification data as shown by item 12 in Figure 1.

e. Additional foldout references and instructions shall be provided as required to safely and accurately guide the troubleshooter. These references shall be provided in other steps identified by the letters b, c, and d in sequence, as required. (See item 13 in Figure 1.)

f. The sequence of instructions shall be arranged to make certain that each step is done safely and that any prerequisite conditions or requirements shall be verified as normal before the technician performs a dependent action.

g. The last element in each step shall define the measurement to be made, its location, and its normal range of values. (See item 14 in Figure 1.)

3.2.2.6 Corrective action column. A corrective action statement shall be located in the right column opposite the measurement instruction to which it applies. (See item 15 in Figure 1.) The statement shall be one of the following:

a. If not, go to Logic Tree X-X.

b. If not, install new (component name).

c. If not, repair (component name).

d. If not, adjust (component name).

e. If not, do Checkout X-X.

f. If not, do Check X in this Checkout.

3.2.2.7 Notes, Cautions, Warnings. Notes, Cautions, and Warnings shall be used as necessary to assure correct operation or testing and equipment or personnel safety. They shall be prepared in accordance with the requirements of 3.1.5.1c.

3.2.2.8 End of Check. The end of each Check in the Checkout, except for a Startup Check, if needed, shall be marked by an end statement. It shall be in capital letters centered on the page just below the last line of the Check to which it belongs. (See item 16 in Figure 1.) This statement shall begin with "END OF" and then repeat the name of the Check.

3.2.2.9 Shutdown Check. When the task analysis indicates there is a probability of fault symptoms to be detected as a result of doing a Shutdown procedure, the last Check of the Checkout shall be a SHUTDOWN CHECK. In other cases, the applicable Shutdown procedure shall be referred to in the preface, or a procedure shall be provided.

3.2.2.10 End of Checkout. After the last step of a Checkout, the rest of the page shall be left blank.

3.2.2.11 Page identifiers. Instead of standard page numbers, a unique identifier indicating the Checkout number only shall be located in the lower outer corner of each page of the Checkout section of the LTTA to provide immediate

access to specific Checkouts. If a Checkout consists of three pages, all three shall bear the original Checkout number. (See item 17 in Figure 1.) It shall be set in bold face type in the form: CO 3-1, CO 3-2, etc. The System/Subsystem/Subject Number (as explained in 3.1.4.1.3) shall appear above each CO page identifier (see item 18 in Figure 1).

3.2.3 Content and development rules for Checkouts. A Checkout shall consist of the instructions, tests, and corrective actions required to check system, subsystem, or equipment outputs that are identified by the task analysis as requiring Checkout to determine if they are within normal tolerance. The instructions and tests shall be arranged systematically in a series of steps. Related groups of steps shall be organized into independent sections of the Checkout, called Check procedures. Each Check procedure within a Checkout shall systematically exercise a section of the system or subsystem through its functions in a manner that permits accurate testing and measurement of the designated outputs. The steps of each Check shall be written so that successful completion will verify normal and safe operation and unsuccessful completion will direct the technician to a corrective action.

3.2.3.1 Development rules. The following development rules for Checkouts shall be observed:

a. Except for Startup and Shutdown Checks, the section of the system under check shall be capable of being checked independently from all other such sections.

b. The number of Checks in the Checkout shall be determined by analyzing the system and its primary functions, subfunctions (if any), primary operating mode, secondary operating modes (if any), and how the various components of the system interact or depend upon each other for continuing normal operation. This analysis shall:

(1) Determine a Checkout sequence that tests first things first (i.e., that no Checkout step presumes a prerequisite condition unless it has first undergone Checkout).

(2) Determine different points at which the Checkout can be entered by a technician and still provide a complete Checkout path that does not bypass any important test(s).

(3) Enable the technician to enter the Checkout process at various logical points to minimize the time it takes to check out and troubleshoot potentially faulty sections of the system.

(4) Enable the technician to enter the Checkout at many points to reduce the time it takes to check the normal operation of the part of the system just repaired.

c. The Checks within a Checkout shall be arranged in a well planned, sequential hierarchy in accordance with the following requirements:

(1) The primary operating mode of the system shall be checked first. Other modes shall be checked in their order of importance within the system.

(2) Checks that take advantage of front panel indicators, built-in test equipment, or symptom detection by seeing, feeling, or hearing abnormal indications shall appear as early in the Checkout as is practicable.

(3) Outputs common to more than one section or operating mode shall be checked at the most advantageous point(s) in the Checkout. Normally, each output shall be checked only once. However, an output may be rechecked where necessary to maintain an unbroken check sequence, to assure system integrity and safety, or to recheck an output that is critical to system functioning in two or more modes of operation.

(4) Along with other pertinent task analysis information, the available test points and test equipment, reliability and failure mode data, component accessibility, and the required activities of the technician shall be analyzed to determine their influence and usefulness in preparing the Checkout. The results of this analysis shall be used to develop the best possible design for each Check and the correct sequence for the Checks.

(5) The resulting sequence of Checks shall examine each active output of the system in the most logical sequence of functions.

3.2.3.2 Development of Checks. The following rules for development of Check procedures shall be observed:

a. Each Check within a Checkout shall consist of the steps required to test and measure the designated active outputs of an independent section of the system. These steps shall appear in the order determined by the task analysis process.

b. The steps within each Check shall be designed to exercise the system as quickly and easily as possible within the limits imposed by system design characteristics, test capabilities, operating modes, functional capabilities, power or signal paths, feedback and feed forward loops, and component failure histories.

c. Successful completion of each step in a Check shall lead to the next step.

d. An abnormal measurement or observation at any step shall be followed by an instruction to do one of the following:

(1) Go to a specific Logic Tree where the trouble isolation and corrective procedure will be completed. This shall be the primary mode of action.

(2) Repair or replace an item that is identified as faulty by the abnormal test results.

(3) Do an alignment or adjustment procedure to return the system to normal.

(4) Go to another Checkout where the checking procedure will be continued until one of the above three corrective actions can be invoked (see 3.2.2.6).

3.2.3.3 Dual-level presentation. Each step in a Check procedure shall be developed for a dual-level presentation that provides a prominent general description of the step, followed by detailed procedures. The general description shall define the task to be done (see item 7, Figure 1) so that an experienced technician can complete the step without further guidance, or with minimal review of the detailed procedures (see 3.2.2.5). The detailed procedures in each step shall be developed for the least qualified troubleshooter defined in the User Profile.

3.2.4 "Preparation for Checkout" instructions. The first part of any Checkout section shall be an introductory group of instructions titled, "Preparation for Checkout." They shall describe what the technician should do before starting the Checkout. When more than one system or major subsystem is included in a volume, these instructions shall be provided for each system or major subsystem. The Preparation instructions shall include any or all of the following, as appropriate:

a. Introduction. The Introduction shall briefly describe the content of the Checkout preparation instructions and how the Checkouts are to be used.

b. Equipment diagrams. Equipment diagrams shall be included in this section and referenced to help the technician locate and identify major parts of the system.

c. Standard test equipment. A table of standard test equipment shall be provided. This table shall provide data in the following four columns: Name, AN Type Designation, Part Number, and Use.

d. Special tools and test equipment. A table of Special Tools and Test Equipment shall be provided. This table shall provide data in the following four columns: Name, AN Type Designation, Part Number, and Use.

e. Notes, Cautions, and Warnings. These items shall be provided in accordance with 3.1.5 and MIL-M-38784.

f. Make-ready requirements and procedures. This section shall provide instructions on how to prepare for Checkout (e.g., provide additional personnel or materials or turn on other equipment). If Startup procedures will not be included in the Checkout in accordance with 3.2.2.3 b, they shall be provided here.

g. Completion procedures and requirements. This section shall provide instructions as needed to ensure that the technician is familiar with any special conditions that are important after completion of the Checkout. Information describing what to do and how to do it shall be provided as necessary to complete the Checkout. If Shutdown procedures will not be included in the Checkout in accordance with 3.2.2.9, they shall be provided here.

3.2.5 List of Checkouts. The front matter for each volume of the LTTA shall contain a list of Checkouts in that volume. In addition, if more than one volume is required for a system, the first volume in the set shall contain a list of Checkouts for all volumes. Each list of Checkouts shall be in single-column format (full page width) and show the following information for each line entry: Number, Title, (No. of Sheets), First Page. When a Checkout is divided into Checks as in Figure 3, the list of Checks shall be indented below the Checkout entry as shown in Figure 5. The number of full or partial sheets on which the Check appears shall be included after the title, using only whole numbers. For example, if a Check covers three-fourths of one page and one-half of the next page, the entry shall be "(2 sheets)."

3.2.6 Review. When the Checkout is considered complete, it shall be reviewed by technically qualified subject matter experts for overall approach, accuracy,

and completeness of the detailed procedures. Their critique should make certain that the following requirements have been fulfilled:

a. All parts of the system or subsystem that require written Checkout procedures have been incorporated in the Checkout.

b. The inputs and outputs that are measurable during each Checkout and their acceptable (in-tolerance) ranges are well documented in the Checkout (see 3.1.5.12).

c. The references to further Logic Tree troubleshooting are accurately identified and correctly used.

d. The number and types of repair, replacement, alignment or adjustment procedures that will be required to return the various outputs to their in-tolerance conditions are accurately documented and correctly used.

e. The characteristics, functions, output test facilities, and operation of the system and its subsystems are organized and developed to best advantage for the User.

f. When all steps of the Checkout have been performed correctly and the results are all within normal tolerances (without faults), the system will operate in conformance with design specifications.

3.3 Logic Tree requirements. The LTTA manual shall contain a Logic Tree section consisting of the detailed instructions, tests, questions, and corrective actions necessary to troubleshoot the system in accordance with the Troubleshooting task analysis. A Logic Tree is a specialized troubleshooting aid that leads a troubleshooter through a preplanned and carefully organized trouble isolation procedure. The procedure shall be graphically presented in a format consisting of test instructions, questions, corrective instructions, and follow-on directives. The Logic Tree shall also contain important supplementary data such as Notes, Cautions, Warnings, waveforms or similar measurement illustrations, as required. Locator diagrams may be provided to help the troubleshooter find and identify the hardware items required to perform Logic Tree steps. Depending on the level of enrichment (3.3.6) required, the locator diagrams may be at the back of the LTTA (minimal or normal enrichment), or may be incorporated with the Logic Tree (full enrichment). The structure of a Logic Tree shall consist of a coordinated set of fault isolating tests, with Yes and No (or similar Either/Or) types of branches. These tests, questions, and branches shall present logical decision paths that guide the troubleshooter through a fault correcting process in the fewest number of steps.

3.3.1 Planning requirements. If not previously established by a formal troubleshooting task analysis, a qualified troubleshooting analyst shall perform a task analysis as required by 3.1.1 to develop a comprehensive and well organized data base and identification of those fault symptoms for which Logic Trees must be prepared. A fault isolation Logic Tree shall be provided for each abnormal observation or measurement identified in the Checkout for which troubleshooting is required. (See 3.2.2.6 and 3.2.3.2.) Each such requirement shall coincide with a fault symptom listed during task analysis.

3.3.1.1 Logic Tree entry points. Each Logic Tree shall be planned to permit direct entry from a fault condition during operation or indirect entry by way of a system Checkout, as follows:

a. Direct entry. When a technician experiences a fault symptom during operation and goes directly to the Logic Tree with the same fault symptom as its title. Note that the List of Logic Trees in the front of the LTTA can be used by the technician as a "fault symptom index." (See 3.2.2.1.)

b. Indirect entry. When a technician experiences a fault symptom during Checkout, and proceeds as the Checkout directs, to a specific Logic Tree for troubleshooting diagnostic and corrective action. The fault symptom which occurred in the Checkout shall be the same as the fault symptom in the title of the Logic Tree.

3.3.1.2 Development package. A development data package shall be assembled for each Logic Tree, although some diagrams and data may be used for more than one package. These packages shall be used for developing Logic Trees, for in-process review, and for Logic Tree Validation. Each package shall include preparer's handwritten notes and data as follows:

a. Title of package. The package title is the fault symptom, which is also the Logic Tree Title. It is derived from the task analysis and Checkout summary.

b. Faulty parts. The assembly, units, or parts that may be causing the fault symptom

c. Failure modes. As required for the potentially faulty assemblies, units, or parts

d. Corrective actions. The conditions to be fulfilled for the system to be returned to normal operation

e. Tests. Those tests necessary during trouble isolation to test suspected faulty parts (e.g., Yes-No questions)

f. Functions. A list of functions dependent upon each test, and which can be isolated by each test

g. Test equipment. A list of the test equipment needed

h. Locator. A list of the types of data or drawings necessary to identify and locate test items

i. Data base. A list of diagrams, engineering or prepared drawings for task analysis. Include the diagram title, drawing number, and revision level. Handwritten notes on data base drawings shall be used to identify applicable hardware items, energy flow paths, measurement criteria, test points, test parameters, expected results, etc.

3.3.1.3 Outline and record. The Development Package shall be used as an outline of the Logic Tree before it is developed and as a historical record of the development of the Logic Tree for later use, when design changes or LTTA improvements are required.

3.3.2 Format requirements. Logic Trees shall be prepared in a specialized format in accordance with the following requirements:

3.3.2.1 Logic Tree title. Each Logic Tree shall begin with and be identified by a title in bold face type at the top of every page, flush with the left margin. (See item 1 in Figure 6.) It shall be prepared as follows:

a. The title shall define a clearly worded fault sumptom that will permit direct entry into the Tree by the troubleshooter. It shall be the same as one of the fault symptoms identified in accordance with 3.3.1.

b. The title shall be numbered by section and sequence in the form: Logic Tree 3-1, Logic Tree 3-2, etc.

c. If more than one page is required, the title shall be repeated at the top of every page and labeled (Sheet 1 of 1), (Sheet 1 of 3), (Sheet 2 of 3), etc., as required.

d. Each Logic Tree shall begin at the top of a new page. Turnpages and foldouts shall not be used.

3.3.2.2 Entry point. The point of entry into each Tree shall be a small oval in which a Checkout is listed. It shall be a reference to the Checkout at which the fault was identified and the Logic Tree referenced. (See item 2 in Figure 6.)

3.3.2.3 Action flow. Action shall begin at upper left and proceed down the page and to the right as required. The various branches and directions of action shall be indicated by heavy lines and arrows. The branch that is followed in a particular troubleshooting situation will depend on which one of the potential faults is occurring and how it affects the results at each test point in the Tree. (See development rules in 3.3.3.1.)

3.3.2.4 Cautions, Warnings. Cautions and Warnings shall be developed in accordance with the requirements of 3.1.5.7 and 3.1.5.8 (see item 3 in Figure 6.) They shall be placed in a bold wavy-line box in the action flow path just ahead of the steps to which they apply. One action flow line shall enter at top or left center and exit at bottom center. The word CAUTION shall be in large bold type centered at the top of the box and underscored. The word WARNING shall be located at top center in a large bold type and underscored with a bold wavy line.

3.3.2.5 Test/decision boxes. A rectangular test/decision box shall be used to establish each branch point in the Logic Tree (see items marked 4 in Figure 6). Brief test instructions in the upper part of the box shall be separated from a decision question in the lower part of the box by a horizontal dashed line. Each test and question shall be developed in accordance with the requirements of 3.3.3.1. Action flow and layout shall be as follows:

a. There shall be one input line to each test/decision box. It shall enter at top or left center. (See item 5 in Figure 6.)

b. There shall be two output (branch) lines from each box. The vertical line shall exit at bottom center and the horizontal branch line shall exit from the right, adjacent to the question. (See items 6 and 7 in Figure 6.) Whenever question results and layout permit, the vertical branch (6) shall be identified by a YES answer and the horizontal branch (7) shall be identified by a NO answer. However, in the final layout the YES and NO positions shall be arranged to provide the most practical Logic Tree structure.

c. All layouts shall be as orderly and straightforward as the sample Logic Trees in Figures 6, 7, 8, 10, and 11. Other layouts are permitted only with approval of the Procurement Agency.

d. If approved by the Procurement Agency, answers other than "Yes" and "No" may be used. For example, in certain situations it may be more effective to use "Red and Green" or "6 volts and 12 volts."

e. If required to support the test, a waveform or other measurement diagram shall be attached to the upper right corner of the test/decision box to which it applies. (See item 10 in Figure 6.) These diagrams shall be prepared in accordance with 3.4.1.

3.3.2.6 Corrective action boxes. A rectangular corrective action box shall terminate the end of each end branch of the Tree. (See items marked 8 in Figure 6.) The instructions in each box shall be developed in accordance with requirements of 3.3.3.4.

3.3.2.7 Notes. Notes may be used as necessary to convey or emphasize essential operating or troubleshooting procedures, conditions, or data. They shall be located in a box at upper right on the Logic Tree page or as available white space allows. (See item 9 in Figure 6.) A reference such as (See Note), (Note 1), (Note 2), etc., shall be placed at the applicable point in the Logic Tree as required. Notes shall be used only where necessary.

3.3.2.8 Continuation branches. Continuation branches of a Logic Tree or branch(es) to other pages shall be symbolized by a circled number. (See item 11 in Figure 6.) For each Tree, these continuation numbers shall begin with "1" and continue in sequence as necessary. The corresponding starting point on the subsequent page shall be a duplicate symbol.

3.3.2.9 Page identifiers. Instead of standard page numbers, a unique identifier indicating the specific Logic Tree number only shall be located in the lower outer corner of each page of the Logic Tree section of the LTTA to provide immediate access to specific Logic Trees. (See item 12 in Figure 6.) It shall be set in bold face type in the form: LT 6-1, LT 6-2, etc. The System/Subsystem/Subject Number (see 3.1.4.1.3) shall appear above each LT page identifier (see Figure 8).

3.3.3 Content and development rules for Logic Trees. A Logic Tree shall consist of the instructions, tests, questions, corrective actions, and follow-on Checkout instructions required for the technician to proceed from a fault symptom through a trouble isolation procedure, to a corrective action, and then to a Checkout procedure to verify that the fault has been properly corrected. The test procedures within a Logic Tree shall direct the technician to exercise the system through a series of carefully chosen discussion points in strategically

organized sequences, called branches. Each such branch shall lead the technician through a strategically organized sequence of tests, questions, and decisions pertaining to a specific section of the system until a specific correctable fault is identified.

3.3.3.1 Development rules. Each Logic Tree shall be developed according to the following rules and strategies:

a. Only one fault symptom is observable at a time and only one fault exists in the system at a time.

b. Each point of test shall be selected to obtain the greatest amount of fault isolation information for the action taken. Instructions for performing the test shall be concise, simply worded, and arranged in specific steps. The complete test, or its steps, shall be preceded by a locator reference to a fold-out, or references, as required to ensure successful completion of the test.

c. Each test shall isolate a meaningful section of the system or subsystem in which the fault can or cannot exist. When a test result shows that the fault does not lie in a specified section of the system, the branch of the Tree representing that section is not accessible for later trouble isolation tests (i.e., no further testing is permitted in that section of the system).

d. The first tests to be done will normally be those that use meters, switches, annunciators, warning lights, and other built-in test equipment. The human senses for sight, sound, and touch should also be used to advantage in the testing process — particularly at the Organizational level.

e. Tests that must be done with external test equipment will normally appear later in the testing process. At the Organizational level, the use of test equipment shall be avoided where possible.

f. Two or more tests shall not cause a closed loop in the strategy (i.e., a situation wherein one fault is isolated from two branches of the Logic Tree).

g. No test shall result in a dead end (i.e., a situation in which the troubleshooter is left to devise a strategy for continuing the trouble isolation procedure).

h. Every test must yield a reliable result compatible with its YES/NO question. There shall be no possibility of a third ambiguous result.

i. A serial (nonbranching) sequence in which one item after another is checked for a pass/fail condition until the fault is found (as in doing a Checkout) is permissible only where it is the only possible sequence for testing.

j. The tests in each branch shall result in accomplishing one of the following, as applicable to the respective maintenance level and authorized maintenance procedures:

(1) Determine which one of two LRUs (Organizational level) or which one of two units, parts, or pieces (Intermediate level) is faulty. (An application of this rule is shown in the area marked "A" in Figure 7.)

(2) Determine that an LRU, or a unit, part, or piece is faulty or that an additional test must be made. (An application of this rule is shown in the area marked "B" in Figure 7.)

(3) Determine that a subassembly Checkout must be made or that another test must be made. (An application of this rule is shown in the area marked "C" in Figure 7.)

3.3.3.2 Test instructions. Test instructions in each Logic Tree shall be developed according to the following rules:

a. Each test in a test/decision box shall be a dual-level presentation that begins with a concise description of the test followed by detailed, step-by-step procedures. The description shall provide an experienced technician with enough information to perform the test or to complete the test with only a quick review of the detailed procedure and the question.

b. The test description shall normally be one line and begin with the word "Check." It shall describe what is to be checked and give a locator diagram (foldout) reference.

c. Detailed instructions shall be presented as numbered steps, simplified as appropriate to the training and experience level of the technician as defined in the User Profile. Provide the following information:

(1) Location where step will be performed

(2) Name and callout number of items used in the test

(3) Action required to perform the test

(4) Additional diagram references, if required, at the beginning of the step to which they first apply.

d. If the test is a simple procedure, the test description and instructions may be combined into a single statement. A typical test will consist of viewing a meter or gauge, making a measurement on a device already in position, listening for a characteristic noise, or setting a switch. In such cases, the illustration reference should precede the statement. An application of this kind of test is shown in the first test/decision box (upper left corner) of Figure 8.

3.3.3.3 Questions The question in each test/decision box shall be complete and concise and usually on one line for quick and easy reading. The question must not repeat procedure data stated in the test description or instruction.

3.3.3.4 Corrective action instructions. Corrective actions in the Logic Tree shall be developed according to the following rules:

a. The instructions in the corrective action boxes at the ends of the branches shall define:

(1) Corrective action to be taken

(2) Follow-on Checkout to be done.

b. Corrective action instructions shall direct one of the following actions:

(1) Repair, replacement, adjustment, or alignment of a specific unit, part, or piece

(2) Further Checkout of the assembly or subassembly to further isolate the fault.

c. Follow-on Checkout instructions shall be written in one of the following forms:

(1) Do Checkout X-X.

(2) Do (assembly name) Checkout X-X.

(3) Do Check X in Checkout X-X.

3.3.4 Draft Logic Trees. A draft layout of each required Logic Tree shall be developed. It shall be available during Contractor in-process reviews and Validation and during Government in-process reviews. Each draft Tree shall be developed to satisfy all Logic Tree requirements, including the following:

a. Section-sequence number. A preliminary section and sequence number shall be assigned to each Tree. It shall be replaced by a final number when all draft Trees have been reviewed, approved, and arranged in the sequence in which they will appear in the manual.

b. Layout sketch. Boxes, data lines, and arrows should be neatly hand sketched with text hand printed in upper and lower case letters as they are to be typeset.

c. Test instructions and questions. The trouble isolation strategy in the form of test instructions and questions shall be developed in accordance with the requirements of 3.3.1, 3.3.2, and 3.3.3.

d. Isolation strategy. The preparer shall include a brief, hand-written summary of the trouble isolation strategy for each Logic Tree. It shall explain how the preparer isolated the faults associated with a fault symptom by using the fewest steps and the most practical Logic Tree sequence. This summary shall not become part of the final Logic Tree.

e. Objective. Adjacent to each test/decision box, the preparer shall print the objective for that particular test and question. These objectives shall be one or two sentences which, when studied together, will outline and define the strategy incorporated in the Logic Tree. These sentences shall not interfere with the basic structure of the draft Logic Tree and shall not be printed with the final Tree.

f. Diagrams. Annotated diagrams used for Logic Tree preparation shall also be attached to the draft Logic Tree.

3.3.4.1 Review of draft Logic Trees. Draft Logic Trees shall be thoroughly evaluated for clarity, logical development, completeness, and technical accuracy by one or more subject matter experts who understand the system and the development of troubleshooting strategies. Copies of the corrected Trees and their attached strategy summaries shall be prepared for examination during Contractor and Government in-process reviews. When reviewed and approved by the Procuring activity, each draft Logic Tree shall become the model for a final Logic Tree.

3.3.5 Final Logic Trees. After the draft Logic Trees have been validated and approved by in-process review, the final Logic Trees shall be prepared from them, using the rules and guidance in this specification. The final layout of each Logic Tree shall maintain the Yes answers in a uniform vertical flow of steps and the No answers in a uniform horizontal flow of steps to the extent that this arrangement is practical for good Logic Tree layout and understandability.

3.3.6 Level of enrichment. Logic Trees shall be developed with a level of enrichment as specified by the Procuring Agency. If no level of enrichment is specified, Logic Trees should be enriched to the normal level (defined in 3.3.6.2, below). Enrichment consists of supplementary data (procedural text and illustrations) which aid the technician to perform fault diagnoses more quickly, but which are not normally crucial to performance. Logic Trees shall be developed with one of the following three levels of enrichment: 1) minimal; 2) normal; or 3) full.

3.3.6.1 Minimal enrichment. Minimal enrichment is exemplified in Figure 10. The procedural data are written to the level of a trained and skilled technician and have no accompanying measurement or locator illustrations (although references to locator diagrams at the rear of the manual can be employed). Compare the level of procedural detail in Figure 10 with that of Figure 8, which has normal enrichment. Both discuss diagnosis of the same fault. The Logic Tree in Figure 8 provides more detailed steps and is aimed at the less skilled technician. It also contains significantly less Logic Tree procedures per page.

3.3.6.2 Normal enrichment. Normal enrichment contains detailed, step-by-step text procedures accompanied by performance measurement diagrams, where appropriate. Logic Trees shall be developed with normal enrichment, as shown in Figures 7 and 8, unless the Procuring Agency specifies minimal or full enrichment.

3.3.6.3 Full enrichment. Full enrichment is exemplified in Figure 11, in which the Logic Tree procedural text is the same as in normal enrichment, but supporting locator illustrations are adjacent to the text. This level of enrichment provides the technician with all the system/equipment functional and physical locator illustrations needed. With full enrichment, foldout locator drawings are not required in a rear section of the manual. In Logic Trees with full enrichment, callout names or numbers on locator artwork shall be restricted to data needed to support that specific Logic Tree.

3.3.7 "Preparation for Troubleshooting" instructions. The first part of any Logic Tree section shall be an introductory group of instructions titled, "Preparation for Troubleshooting." They shall describe what the technician should do before starting to troubleshoot with the Logic Trees. When more than one system or major subsystem is included in a volume, these instructions shall be provided for each system or major subsystem. The Preparation instructions shall include any or all of the following, as appropriate:

a. Introduction. The introduction shall briefly describe the content of the troubleshooting preparation instructions and how the Logic Trees are to be used.

b. Equipment diagrams. Reference shall be made to the equipment diagrams in the Checkout section or, if appropriate, to additional ones provided in this section (see 3.2.4 b).

c. Standard test equipment. Reference shall be made to the table of Standard Test Equipment provided in the Checkout section; or, where the Checkouts and Logic Trees are in different volumes, another table may be provided (see 3.2.4 c).

d. Special tools and test equipment. Reference shall be made to the table of Special Tools and Test Equipment provided in the Checkout section; or, where the Checkouts and Logic Trees are in separate volumes, another table may be provided (see 3.2.4 d).

e. Notes, Cautions, and Warnings. These items shall be provided in accordance with 3.1.5.1 c and MIL-M-38784.

f. Make-ready requirements and procedures. This section shall provide instructions on how to prepare for troubleshooting. Reference shall be made to Startup procedures in the Checkout section or in another manual.

g. Spot Check tables. A Spot Check table shall be included for those special situations wherein: 1) only one fault can cause a fault symptom; 2) the corrective action for a fault is obvious from the nature of the fault symptom or system troubleshooting history; or 3) the fault is a critical one that must be addressed and corrected immediately — thus, no further trouble isolation procedure is required. The fault symptoms included in this table shall be those identified by the Failure Mode and Fault Symptom analysis. This table shall be prepared as shown in Figure 9. The title shall include the system or subsystem name and "Spot Checks." Each title shall be numbered sequentially by section, in the form: Table 6-1, Table 6-2, as required.

h. Completion procedures and requirements. This section shall provide instructions as needed to ensure that the technician is familiar with any important special conditions after Troubleshooting and Checkout are complete.

3.3.8 List of Logic Trees. The front matter for each volume of the LTTA shall contain a list of Logic Trees in that volume. When a system requires more than one volume, a list of Logic Trees for all the volumes shall be provided in the first volume. These lists of Logic Trees are an important troubleshooting aid, especially to the more experienced troubleshooter who may be able to skip the detailed Checkout by referring to a list of Logic Trees for the needed troubleshooting aid. Since each Logic Tree title is a fault symptom, a list of Logic Trees is effectively a Fault Symptom index. Each list of Logic Trees shall provide the following information:

a. Logic Tree number in the form: 3-1, 3-2, etc.

b. Logic Tree title. This title must be a complete fault symptom as written at the top of the Logic Tree.

c. If the Tree appears on more than one sheet, the number of sheets, in the form (2 sheets), (3 sheets), etc.

d. Page identifier in the form: LT 3-2, LT 3-3, etc.

3.4 Illustration requirements. LTTAs developed with normal enrichment requirements shall contain locator, equipment, and measurement diagrams to support the Checkouts and Logic Trees. (LTTAs with minimal enrichment or full enrichment shall contain illustrations as defined in 3.3.6.) If optional Supporting Aids are stipulated in the contract Statement of Work, functional block diagrams and schematic diagrams shall also be supplied (see 3.5). Illustrations shall be line drawings in accordance with MIL-M-38784, except for certain waveforms and equipment illustrations as defined in 3.4.1 and 3.4.2. Locator (and functional block and schematic, if required) diagrams shall be foldouts with blank aprons and shall be located at the end of the section, chapter, or volume they support. They shall be prepared in accordance with the following general requirements:

a. Each of these illustrations shall be designed to support the Checkouts and Logic Trees, and other sections of the LTTA. The amount and arrangement of information on each diagram shall be developed to best serve the needs of the User.

b. Captions shall be numbered by section and sequence, such as: F/O 9-1, F/O 9-2, etc.

c. Each set of foldouts shall be preceded by an introductory page containing a Title, brief Description, and Purpose of the diagrams. If required to support the troubleshooting effort, this page shall also contain a general reference to related diagrams in other manuals.

d. S/S/SN numbers shall be used on Organizational diagrams in accordance with 3.1.4.1.3.

3.4.1 Measurement diagrams. Measurement diagrams shall be supplied on Checkouts and Logic Trees to show: what, where, and how to make measurements such as electronic waveshapes, mechanical settings, or motion or distance tests. If required, they shall also be shown on Supporting Aids like functional block diagrams. Measurement diagrams are small, special-purpose illustrations located on Checkout and Logic Tree pages. They shall not be captioned as figures or foldouts, but a descriptive title may be applied to clarify their purpose and use.

3.4.1.1 Waveforms. When a waveform measurement diagram is required, it shall be a reversed line drawing (white on black) except where the contractor can show cost and time savings by using oscillograms and approval is granted by the Procuring activity. The waveform shall show the normal signal at a designated test point in a circuit when using the authorized oscilloscope as well as the specific settings. These settings shall be printed as close to the waveform as possible, retaining good visual presentation and clear separation from other information. Capital letters and a medium or bold type shall be used. (See Figures 3 and 7.)

3.4.2 Equipment diagrams. Equipment diagrams shall be supplied to show the general arrangement and installation of the major hardware items in a system, subsystem, or equipment. They shall be prepared as line drawings and oriented to show the equipment as it will be viewed by the troubleshooter. They shall normally be used only with descriptive or instructive information as is found in the Preparation for Checkout and Preparation for Troubleshooting portions of the LTTA.

3.4.2.1 Photographs. Photographs may be used in lieu of line drawings when authorized by the Procurement Agency.

3.4.2.2 Size and location. Equipment diagrams shall be partial or full page size, but not foldouts. Turnpages shall be avoided. Equipment diagrams shall be designated as figures and located close to the printed information that they support. Full page equipment diagram pages shall be printed both sides of the sheet, unless otherwise specified. Captions shall be numbered sequentially throughout the book.

3.4.3 Locator diagrams. Locator diagrams shall be foldouts that show component configurations and convey physical locations on systems, subsystems, equipments, and assemblies. Diagrams shall portray item identification, measurement or test points, and other data as required to ensure successful Checkout and fault isolation. Diagrams shall show only those parts of the equipment or unit that are pertinent to the text they support. Example of locator diagram requirements are demonstrated in Figures 12 and 13.

3.4.3.1 Orientation. Locator diagrams shall be oriented to show the equipment as it will be viewed by the User.

3.4.3.2 Callouts. Each item needed for the troubleshooting task shall have a callout line and number. Callouts shall be limited to those necessary for the LTTA procedures. Callout 1 shall be placed at top center of the illustration and all other callouts shall follow clockwise in numerical sequence. A legend shall be placed on the illustration or its apron to show correlation between callout numbers and item names. Whenever an equipment component is shown on two or more illustrations, its name and callout shall be consistent.

3.4.3.3 General location view. When an equipment assembly or significant component is first referenced and its location has not yet been established, a small general location view shall be used to identify its location within the equipment or system. An oversized arrow as shown in Figure 13 shall be inserted from the assembly or component position on the location view to an enlarged, detailed view. Leader lines shall then be used to locate and identify needed items.

3.4.4 Functional block diagrams. Functional block diagrams, if required, shall be foldouts that show schematically the functional interrelationships and pathways of energy, signals, power, fluid, etc., as well as significant feedback or feed forward loops, between the stages or components of a system, subsystem, or equipment. The functions of the system or equipment shall be clearly shown in block diagram style. All appropriate troubleshooting test points shall be indicated and identified. Measurement diagrams, if required to show the value or signal to be measured at a test point, shall be located in proximity to the applicable text point. They shall be connected by a diagonal dashed line or the test point shall be called out adjacent to the measurement diagram. Functional block diagrams shall be copies or adaptations of existing illustrations, finished copies of diagrams prepared for use during the task analysis, or ones specially prepared to meet the requirements of this specification. Samples of these requirements are shown in Figures 14 and 15.

3.4.5 Schematic diagrams. Schematic diagrams, when required, shall be fold-outs prepared and presented in accordance with MIL-M-38784. Whenever feasible, they shall be copies or adaptations of existing illustrations or finished copies of diagrams prepared for use during the task analysis. A sample schematic is shown in Figure 16.

3.5 Supporting Aid requirements. Supporting Aids are optional elements of the LTTA, and therefore they shall be provided only when specified by the contract Statement of Work. When required, Supporting Aids shall be provided to give the troubleshooter the wherewithal to develop a trouble isolation strategy to isolate those troubles for which it is not practical to provide proceduralized troubleshooting aids such as Checkouts and Logic Trees. Supporting Aids provide the experienced technician with detailed technical data to enable diagnosis of faults by examining energy flow, mechanical interrelationships, and engineering drawings for those faults not covered elsewhere in the LTTA. Supporting Aids consist of troubleshooting strategies, functional block diagrams, and schematic diagrams. Specific requirements for the strategies are established in this section, but requirements for the diagrams are specified in 3.4.

3.5.1 Functional block diagrams. If Supporting Aids are required by the contract, functional block diagrams shall be supplied as explained in 3.4.4.

3.5.2 Schematic diagrams. If Supporting Aids are required by the contract, schematic diagrams shall be supplied as explained in 3.4.5.

3.5.3 Troubleshooting strategies. When required, a troubleshooting strategy shall be provided for each system or subsystem included in the LTTA. Each strategy shall include, but not be limited to, the following elements:

a. A brief description of the system and its characteristics with respect to troubleshooting, including a list of the types of troubles not covered by Logic Trees

b. How to use functional block diagrams and schematic diagrams in developing a trouble isolation strategy

c. References to pertinent data in applicable maintenance manuals (e.g., system description, theory of operation, functional descriptions)

d. Identification and location of test points and references to locator diagrams and other diagrams

e. List of test equipment to be used and applicable supporting materials

f. Brief description of recommended approach and techniques for isolating troubles

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use Contractor or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Contractor inspection. All material furnished in accordance with this specification shall be inspected by the supplier for conformance to the applicable requirements herein. Contractor shall have the primary responsibility for in-process quality assurance during the development phase of the LTTA manual, and shall be responsible for its technical completeness and integrity as presented for Government acceptance. The contractor shall be further responsible for correcting any errors or omissions detected by the Government before acceptance, as well as after acceptance for the period of time stated in the contract. In-process quality assurance shall be conducted in accordance with a Quality Assurance plan as required in 4.4 and product integrity shall be assured by a Validation program as required by 4.6. If subcontractors perform any of the manual development, the contractor shall be responsible for assuring that drafts and final manual conform to the contract and specification requirements. The extent of control invoked and exercised by the contractor shall be identified in the Quality Assurance plan, and the contractor shall inspect all materials upon receipt from the subcontractor.

4.3 Government inspection. All material furnished in accordance with this specification shall be subject to inspection, verification, and approval or disapproval by the Government as specified by the terms of the contract. Inspection/Verification will be performed by the Government prior to acceptance. Government inspection will include periodic in-process reviews and inspections during manual development, and verification of the manuals submitted by the contractor. In-process reviews will be performed by the Government at key points in the LTTA development process. Additional unscheduled reviews will be performed

as desired by the Government. The reviews will be conducted in the contractor's facility or an equipment site, or both, as appropriate. Key points of in-process review should include the following items:

a. Task analysis efforts and products

b. Draft Checkout procedures

c. Preparation for Checkout instructions

d. Fault Symptom lists

e. Draft Logic Trees

f. Logic Tree development package

g. Logic Tree lists

h. Preparation for Troubleshooting instructions

i. Planning for measurement diagrams and foldouts

j. Planning for Supporting Aids (if needed)

k. Draft appendices (if needed)

l. Troubleshooting strategies

4.4 Quality Assurance plan. The contractor's Quality Assurance program shall be conducted in accordance with a well defined plan. This plan shall document the contractor's provisions and methods for assuring the quality of the LTTA manuals, and it shall be incorporated in the Publication/QA plan required by 3.1.6. The Quality Assurance section of the plan shall be subject to the same approval requirements as the Publication section, and shall contain the following elements:

a. Details of the proposed in-process Quality Assurance program — if an inspection system in accordance with 4.5 is a requirement of the contract, details of the system including inspection methods, records keeping, corrective action, and responsibilities of assigned departments and personnel

b. Validation plan, including methods and procedures, records keeping, personnel assignments, correction and revalidation, and scheduling

c. Provisions for participation in and support of Government in-process reviews including facilities, equipment, and data availability and access, personnel participation, and documentation of and compliance with guidance provided

d. Methods and procedures for controlling quality of products prepared by the contractor

4.5 Contractor inspection systems. When required by the contract, the contractor shall establish and maintain a continuous in-process inspection system for the purpose of assuring a quality LTTA, beginning with the earliest development stages. It shall be a written system conducted, documented, and maintained in accordance with the requirements of this section and applicable portions of MIL-I-45208 cited herein. The system shall provide comprehensive control of the development and validation of the manuals to assure that they meet the requirements of the contract and this specification, and are adequate for the intended use. If a quality program in accordance with MIL-Q-9858 is a requirement of the equipment program, it may be used instead (in whole or in part), at the contractor's option to permit a single, uniform quality system. When the contract includes preparation of a formal task analysis (MTI&A) effort, it shall be integrated with the overall technical manual Quality Assurance program. If the contract requirements for Contractor inspection conflict with this specification, the contract shall govern. The contractor's responsibilities for the inspection system shall be in accordance with MIL-I-45208. The contractor shall use Contractor or other manpower, facilities, and services as approved by the Procuring Agency. Quality Assurance personnel shall not be the same persons as those preparing the item being examined, but shall be qualified by training and experience to assess LTTA requirements, products, and Validation methods.

4.5.1 Detailed requirements. Contractor inspection systems shall incorporate the following requirements:

a. Inspection instructions. Directions for inspection shall be documented by clear, complete, and current instructions as prescribed in MIL-I-45208. The instructions shall include sampling procedures, methods of checking the adequacy of analysis procedures, and Checklists for assessing the content and completeness of LTTA materials. Criteria for approval and rejection shall be given. Inspections shall be conducted in accordance with the approved Quality Assurance plan. Sampling methods shall be applied when deemed suitable during the development period. However, all LTTA procedures must be subjected to 100 percent Validation prior to submission to Government.

b. Records. The results of all inspections shall be recorded in accordance with MIL-I-45208. The records shall indicate the products sampled, the nature and number of observations made, the number and type of deficiencies found, and the nature of corrective action taken as appropriate.

c. Corrective action. When defects are found during inspection, the contractor shall take prompt action in accordance with MIL-I-45208 to correct the defects or conditions that could result in the submission of a defective manual to the Government.

d. Source data. The inspection system shall provide for procedures which assure that the latest source data are being used for LTTA development.

e. Validation. The inspection system shall provide procedures for monitoring the Validation process by Quality Assurance personnel to ascertain that it is being conducted in accordance with the requirements of 4.6 and the Validation plan, that Validation results are properly recorded, and that LTTA materials are corrected as necessary.

4.5.2 Checkout QA Checklist. The contractor shall be prepared to show at any time that all draft or final Checkouts contain the following characteristics:

a. Each Checkout is accurate, complete, and free of redundant steps.

b. Each Check within a Checkout is independent of other Checks and will, if all steps are completed successfully, accurately determine that the applicable section of the system is operating properly.

c. Each step is correctly developed for dual-level presentation, is accurate, and easy to understand.

d. Each Checkout is supported by accurate diagrams.

e. User instructions are concise and easy to understand.

f. Measurement diagrams accurately represent the in-tolerance condition for the applicable measurement.

g. Oscilloscope settings, if required, are correct, complete, and easy to understand.

h. Only authorized tools and test equipment are used in the Checkout procedures.

i. The right column contains accurate directions to go to a Logic Tree, to do a subassembly Checkout, or to do a corrective maintenance action.

4.5.3 Logic Tree QA Checklist. The contractor shall be prepared to show at any time that all draft or final Logic Trees contain the following characteristics:

a. Each Logic Tree structure is accurate, complete, and free of redundant loops.

b. Each step is correctly developed for dual-level presentation, is accurate, and easy to understand.

c. Each Logic Tree is supported by accurate diagrams.

d. User instructions are concise and easy to understand.

e. Measurement diagrams accurately represent the in-tolerance condition for the applicable point of test or measurement.

f. Oscilloscope settings, if required, are correct, complete, easy to understand, and in the best position for easy reading.

g. White space was used wisely to separate Logic Tree elements, to facilitate easy reading and rapid scanning, and to clearly depict the logic path.

h. Only authorized tools and test equipment are used in the Logic Tree fault isolation procedure.

i. Corrective actions and follow-on Checkout procedures are accurately identified.

j. There is a Logic Tree for every applicable fault symptom identified in the system Checkout procedure.

4.6 Validation. Prior to submission to the Government, the LTTA manual shall be validated by the contractor for adequacy, accuracy, and completeness in accordance with the following requirements:

a. Validation shall constitute a complete and thorough check of data and procedures to ensure overall quality and technical integrity of the products.

b. Validation may be performed at the contractor's facility, an equipment site, at the subcontractor's facilities, or a combination of these as determined to be most suitable for the purpose.

c. Validation shall be conducted by qualified Contractor technical personnel and Quality Assurance representatives in accordance with the approved Publication/QA plan. The Government reserves the right of witnessing Validation by representatives of the Procuring activity; therefore, the contractor shall notify the Procuring Agency in advance of scheduled Validation activities.

d. The contractor shall validate all task analyses, data Checkout procedures, the Logic Tree development package, draft and final Logic Trees, diagrams, and troubleshooting strategies developed for use in the LTTA manual.

e. The LTTA manual must be completely validated.

f. Equipment shall be dedicated for operation, alignment, adjustment, simulation of malfunctions, troubleshooting and test as necessary to the Validation process.

4.6.1 Validation procedures. The following procedures shall be observed to comply with Validation requirements:

a. All procedures and steps shall be validated 100 percent on the equipment.

b. The adequacy of the task steps and illustration references of the Checkout and Logic Tree section shall be checked by actual performance. Only the LTTA manual and authorized tools and test equipment shall be used. The objective shall be 100 percent Validation of technical accuracy, adequacy, and performability by target User personnel.

c. Simulation in lieu of full troubleshooting performance shall be used only as necessary to prevent degradation of parts, pieces, or components associated with the faulty elements. Prior approval of the Government shall be obtained for all troubleshooting simulations.

d. Contractor personnel shall perform all Checkout and troubleshooting procedures on operational and authorized equipment, using only information provided in the LTTA manual. Additional information shall be limited to that required for safe operation of equipment and protection of personnel. Any procedure that cannot be fully validated shall be revised and re-performed until it meets the criteria of this specification.

e. The contractor shall determine if adequate Cautions, Warnings, and Notes have been included at appropriate places to ensure personnel safety and equipment integrity.

4.6.2 Checkout procedures and Logic Trees. Checkout procedures and Logic Trees shall be validated to ensure that they meet the following requirements:

a. The Checkout procedure must include steps that will expose every fault or failure mode identified during the troubleshooting task analysis and therefore requires a Logic Tree.

b. The Checkout procedure must be efficiently structured to ensure against redundant steps, omissions, overlapping Checks, and incomplete endings.

c. Every fault symptom generated by the Checkout shall have a corresponding Logic Tree and shall be accounted for in the list of Logic Trees.

d. The task analysis shall be validated to ensure that Logic Trees were not incorrectly omitted for certain failure modes or faults.

e. Every locator diagram shall correctly correlate with the Logic Trees it supports.

f. Every Logic Tree shall be free of closed loops, duplicated corrective actions, and improper branching.

g. Decision questions in a Logic Tree shall be concise and accurately worded to require only a YES or NO answer, unless an appropriate substitute is authorized.

4.6.3 Tolerance ranges. In the process of validating Logic Trees, the contractor shall determine the full range of tolerance values given for pressure, motion, voltage, current, resistance and waveform readings (see 3.1.5.12). The basis for these determinations shall be the tolerance ranges listed in Checkout procedures and Logic Trees. The full range for each reading shall be established by simulating the failure mode in a manner that allows the tolerance limits to be observed (i.e., the points in the range at which the fault symptom(s) appear. When approved by the Government, and at the option of the contractor, a set of design, engineering, test or production reports showing the required tolerance ranges can be inserted in Validation results in lieu of further trials.

4.6.4 Personnel. Validation proceedings shall include the following personnel:

a. One or more Contractor subject matter experts who can attest to the technical accuracy of data, procedures, analysis, and decision steps and who can certify appropriateness to the maintenance concept and test equipment support plan

b. Contractor Quality Assurance representatives who are empowered to ensure that Validation effort meets contract and specification requirements

c. One or more subject performers who have training and technical capability about the same as intended User

d. A Government witness (Government option)

e. Supervisory and writing personnel as required to record Validation changes and support the Validation process.

4.6.5 Certification. Contractor shall prepare a Validation Certificate at the conclusion of Validation proceedings. It shall be signed by two or more management personnel empowered to certify to the Government that the LTTA manual is accurate, complete, and in accordance with all requirements and intents of the contract with respect to meeting the needs of the intended User specified by the Government. The Certificate will also be signed by the Government Validation witness. This signature shall only certify that Validation was performed and shall not be an approval of the methods, format, or data used for the Validation process; and shall in no way relieve the contractor of responsibility for satisfactory completion of contractual or specification requirements. Verification and Warranty terms and conditions shall remain in effect.

4.6.6 Corrections and revalidating. Contractor shall correct all Contractor errors and necessary improvements to the LTTA at no cost to the Government including those found during the Verification and Warranty periods. Errors introduced by Government-furnished data shall be corrected by the contractor at a cost agreed upon by the contractor and the Government or as specified in the contract. All information corrected or restructured as a result of Validation shall be revalidated and recorrected as necessary until it meets the requirements of this specification.

4.6.7 Records. The contractor shall prepare and maintain a record of Validation proceedings showing dates, material validated, findings, action taken, and names of participants. The Procuring activity shall have the right to examine these records at the contractor's facility.

4.6.8 Government-furnished data. The contractor shall include in Validation records, a listing of Government-furnished data and a certification that all such data are correctly used in the manuscript. The contractor is not responsible for the adequacy and accuracy of Government-furnished data, but is responsible for notifying the Government immediately if inaccurate, inconsistent, or incomplete data are discovered.

4.7 Verification. Verification is a Government process and will be directed by Government representatives from the Contracting and Procuring agencies. In addition, the contractor shall be represented by technical personnel who are capable of correcting procedures or data found to be inaccurate or inappropriate for personnel defined in the User Profile.

4.7.1 Scope and participants. Representatives of the Government will perform a Verification review to ensure the adequacy, accuracy, and completeness of the LTTA manual. The Government will use task performance personnel who most nearly represent the personnel defined in the User Profile. They will perform the Checkouts and Logic Tree trouble isolation procedures using only the LTTA manual and authorized tools and test equipment. Qualified Government technical personnel will observe the proceedings and annotate a copy of the manuscript as necessary to record the results. The Government will verify that the contractor has complied with requirements set forth in 4.5 and 4.6, as well as 3.1 through 3.5.3. If problem areas are discovered during Verification process, they shall be recorded by Government and Contractor observers. Errors shall be corrected promptly by the contractor and the manual immediately resubmitted for Verification.

4.7.2 Duration. All Spot Checks and Logic Trees shall be completely verified to make sure the end User has an accurate set of troubleshooting aids. Inasmuch as degrading faults will not be inserted in equipment, this process shall be continued in the operational environment for those Trees that cannot be verified during the primary Verification cycle. The contractor's responsibility for this part of the Verification process shall be continued during Warranty as specified in 4.7.4. It will be the responsibility of the Procuring activity to achieve 100 percent Verification within the primary Verification period if possible, and to assume responsibility for any deficiencies discovered after Warranty expiration.

4.7.3 Correction of errors. The contractor shall correct errors at no cost to the Government, including those found during the Warranty period. Errors introduced by Government-furnished data shall be corrected by the contractor at a cost agreed upon by the contractor and Government or as specified in the contract. All information corrected or restructured as a result of Verification shall be revalidated and reverified as necessary until it meets the requirements of the contract and this specification.

4.7.4 Warranty. The technical data, analysis, and instructional content of LTTA manuals shall be under Contractor warranty for three years from date of acceptance by the Government.

4.8 Prepublication review. Representatives of the Government will perform a prepublication review of the final reproducible copy as quickly as Verification corrections can be completed by Contractor. For this review, the contractor shall expeditiously incorporate corrections and improvements found to be necessary during Verification and prepare the manuscript in final reproducible form. The contractor shall then prepare the number of proof copies required by the contract. Prepublication review shall normally be held in the contractor's facility where final corrections can be made swiftly so as to avoid delay of reproducible copy delivery. The contractor shall assist by providing a suitable review facility and qualified personnel who can resolve technical and administrative problems while the review is in progress.

5. PACKAGING

5.1 Packaging. Packaging, packing, and marking shall be in accordance with MIL-M-38784 and MIL-P-38790.

6. NOTES

6.1 Intended use. Logic Tree Troubleshooting Aid manuals prepared in accordance with the requirements of this specification are intended for use by Organizational and Intermediate maintenance personnel in efficiently performing system/equipment Checkout, trouble isolation, and corrective maintenance on a designated system or equipment.

6.2 Ordering data. Purchasers should exercise any designed options offered herein, and procurement documents should specify the following:

a. Title, number, and date of this specification

b. All other applicable specifications and documents invoked and identified in order of precedence

c. Identification of the system for which the LTTA is to be written and the maintenance level, Organizational or Intermediate, or both

d. Clear definition of the relationship between each LTTA and the maintenance manual set with which it will be used (3.1.3)

e. A preliminary target User profile, based on the capabilities of personnel as they graduate from respective training programs and the applicable maintenance concept (3.1.1 and 3.2.1.1)

f. The maintenance concept to be reflected in the LTTA (and the task analysis) (3.1.1 and 3.2.1.1)

g. The level of enrichment for Logic Tree development (3.3.6)

h. Optional Supporting Aids (if appropriate, specify that the contractor may make recommendations) (3.1.2.2 and 3.5)

i. Pocket or standard size manual has been specified for an Organizational LTTA (3.1.4.1.1)

j. The Government's plan, procedures, and requirements for conducting in-process reviews (4.3)

k. The Government's plan for Verification requirements and procedures (4.7)

l. The number of days within which the Publication/Quality Assurance plan is to be submitted, reviewed, and returned (3.1.6)

m. The number of proof copies for in-process and Prepublication reviews (4.8)

n. A Fault Code/LTTA Cross Index or Indexes, if required (7.1).

6.3 Data requirements. When this specification is used in a procurement which incorporates a DD Form 1423 and invokes the provisions of 7-104.9(n) of the Armed Services Procurement Regulations, the data requirements identified below will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of ASPR 7-104.9(n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this specification is cited in the following paragraphs:

Paragraph	Data Requirement	Applicable DID
3.1.6	Technical Order Publication Plan	DI-M-3401
4.6.5	Validation Record (Tech Orders)	DI-M-3408

(Copies of data item descriptions required by the contractors in connection with specific procurement functions should be obtained from the Procuring activity or as directed by the contracting officer).

6.4 Terms and definitions. The following important terms and definitions are used throughout this specification. An understanding of each is necessary to enable the contractor to develop an effective LTTA manual:

6.4.1 Action tree: A branching-tree diagram depicting strategy and tests of a fault isolation procedure, showing steps required to isolate each fault that can cause the symptom. An important task analysis product and the basic building bloc' for the Logic Trees in a LTTA.

6.4.2 Checkout (CO): An orderly, detailed procedure for checking all measurable outputs of an equipment or system to determine if it is working properly, and from which a set of fault symptoms is derived. Also used for determining if a corrective maintenance action has restored an equipment or system to normal operation.

6.4.3 Enrichment: Supplementary technical data such as instructions, diagrams, and step details that make a Logic Tree easier to use and more effective than an action tree.

6.4.4 Fault: A defective piece, part, unit, subassembly or assembly, which causes or contributes to a fault symptom.

6.4.5 Fault Symptom: Observable or measurable abnormal indication, operation, or function caused by a fault in an equipment or system.

6.4.6 Functional block diagram: A line drawing depicting functional relationships between principal subsections of an equipment or system, including energy, power, or signal flow paths, significant feedback and feed forward loops, critical measurement data, test points, and other data important for fault isolation.

6.4.7 Locator diagram: A detailed line drawing showing configuration, location, and nomenclature of assemblies, subassemblies, units, parts and pieces required in a troubleshooting process, including required test points and measurement data or diagrams.

6.4.8 Logic Tree (LT): A schematic representation of the logical and orderly decision-making process and preplanned strategy followed by a technician to isolate faults to a replaceable or repairable unit.

6.4.9 LTTA: 1) Acronym for Logic Tree Troubleshooting Aid; 2) A specialized troubleshooting manual containing Logic Trees, Spot Checks, system Checkouts, locator diagrams, and measurement diagrams. May also contain supporting diagrams and troubleshooting strategies.

6.4.10 Measurement diagram. A small, uncaptioned illustration placed on a Checkout, Logic Tree, or locator diagram to show what and how to measure, such as a close tolerance in a mechanical system, a motion or distance, or an electronic waveform.

6.4.11 MTI&A. Maintenance task identification and analysis. The preparatory analysis phase of identifying troubleshooting tasks, researching data, and establishing fault diagnosis strategies for use in LTTA development. See also Task Analysis (6.4.1.3) and AFHRL-TR-79-50 (2.1).

6.4.12 Spot Check. A quick check to cut fault isolation time, especially in mission-critical situations.

6.4.13 Task analysis. The identification, itemization, utilization, and analysis of tasks and troubleshooting aids required to maintain and troubleshoot a system.

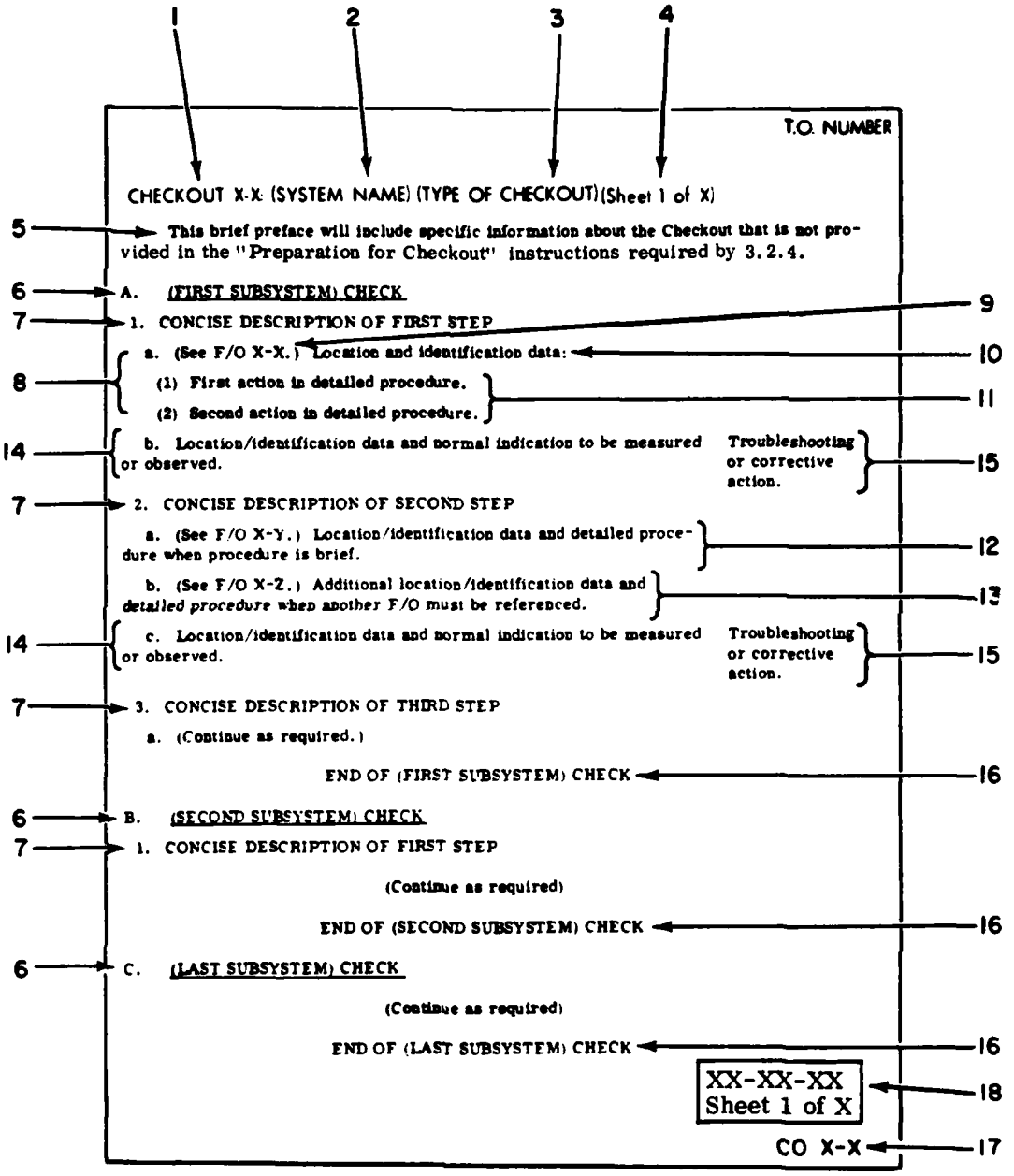


FIGURE 1. Sample general format for a checkout.

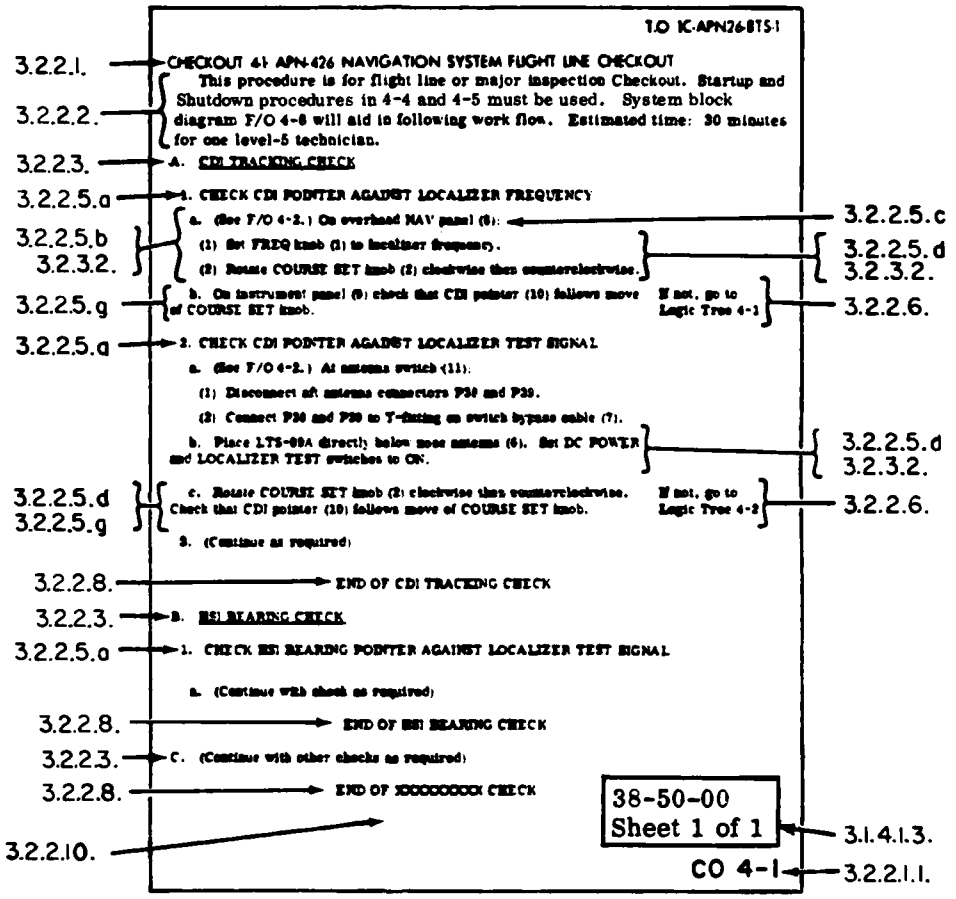


FIGURE 2. Sample organizational level checkout.

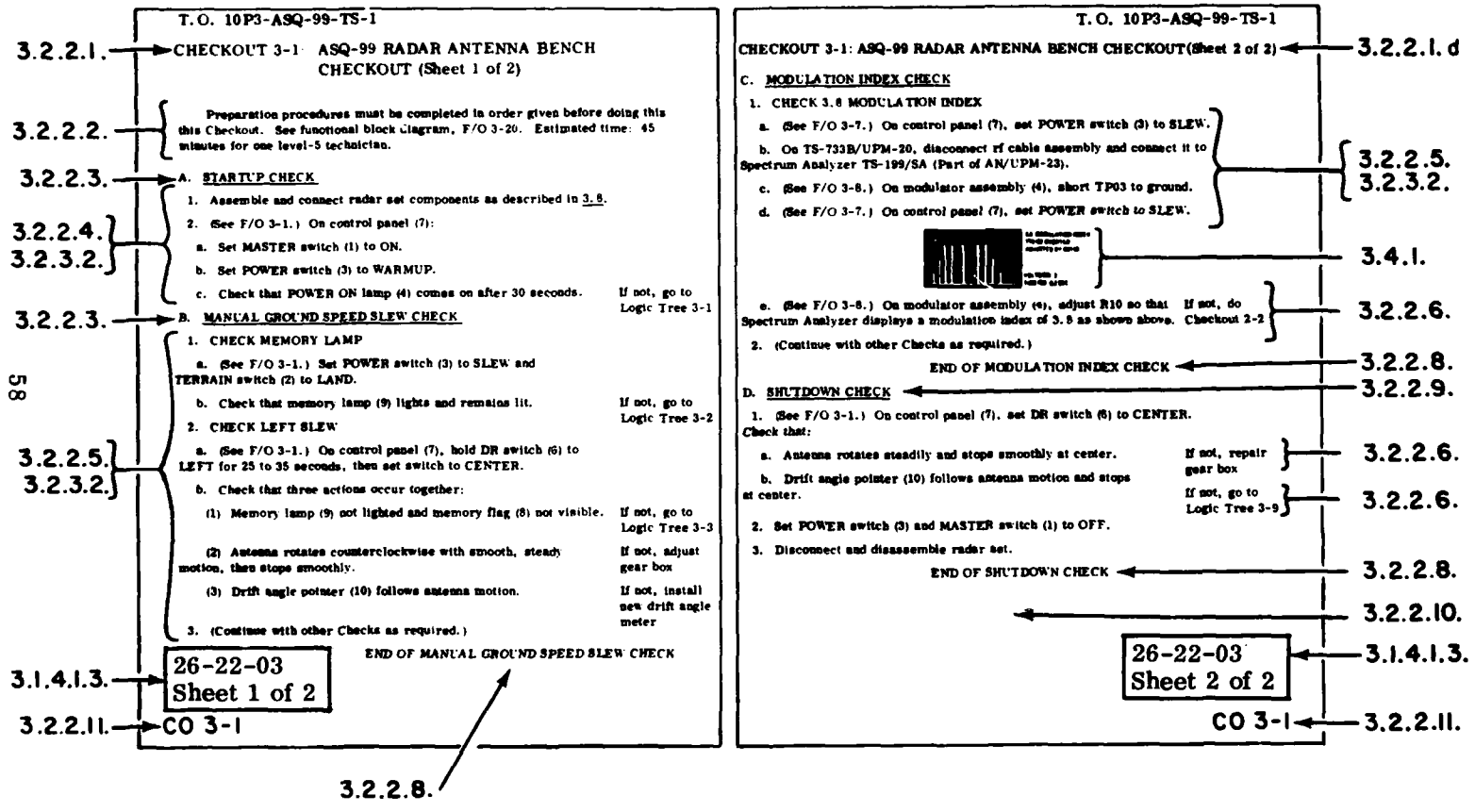


FIGURE 3. Sample intermediate level checkout for electronic system.

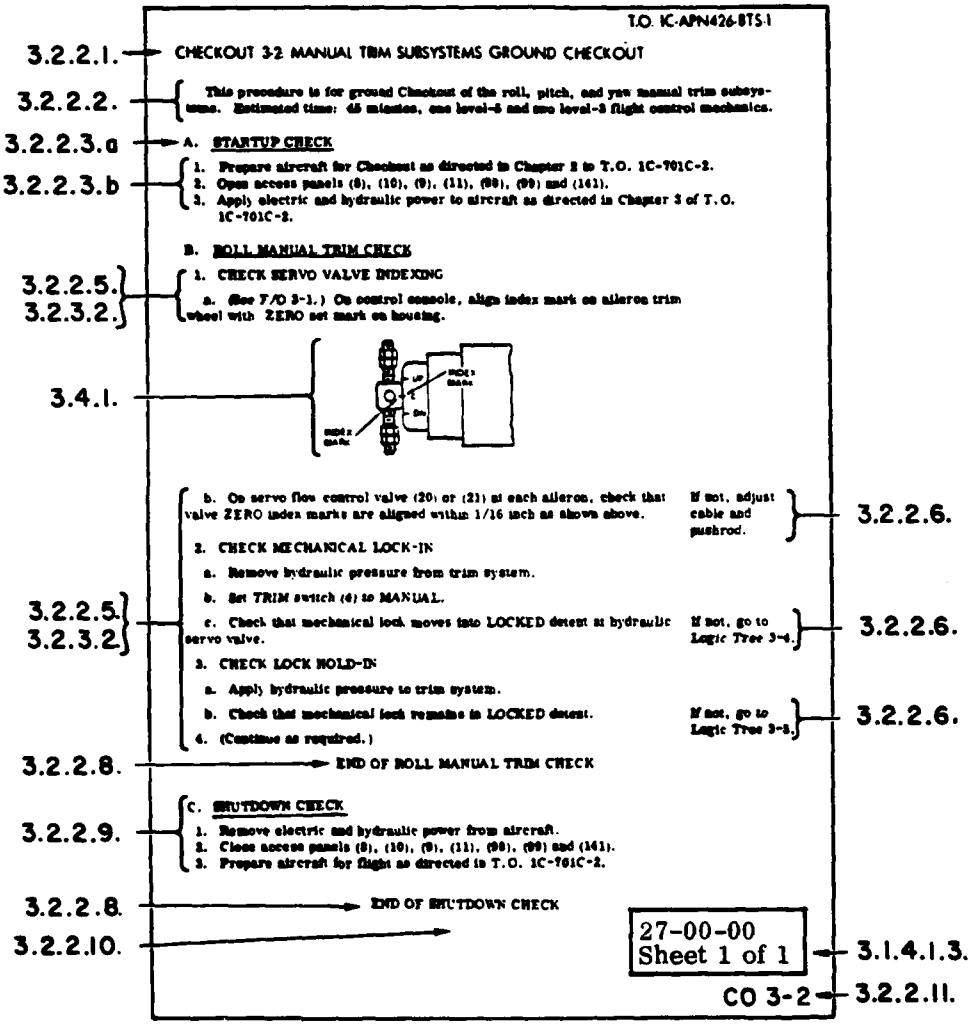


FIGURE 4. Sample checkout for mechanical system.

LIST OF CHECKOUTS

Checkout/Check		Page
3-1	ASQ-99 Radar Antenna Bench Checkout (2 sheets)	CO 3-1
	A. Startup Check (1 sheet)	CO 3-1
	B. Manual Ground Speed Slew Check (1 sheet)	CO 3-1
	C. Modulation Index Check (1 sheet)	CO 3-1
	D. Shutdown Check (1 sheet)	CO 3-1
3-2	ASQ-99 Receiver-Transmitter Bench Checkout (5 sheets)	CO 3-2

FIGURE 5. Sample list of checkouts

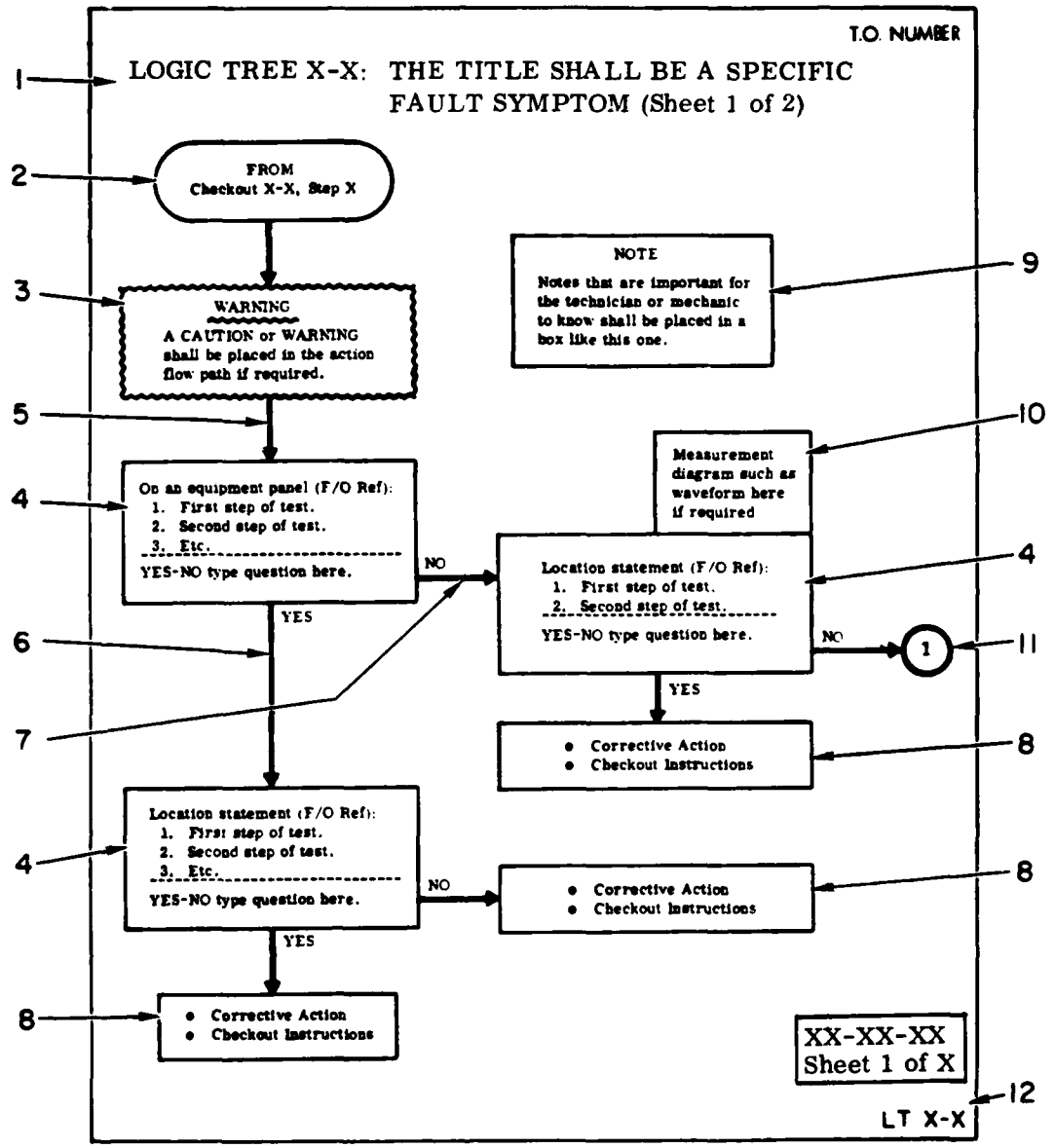
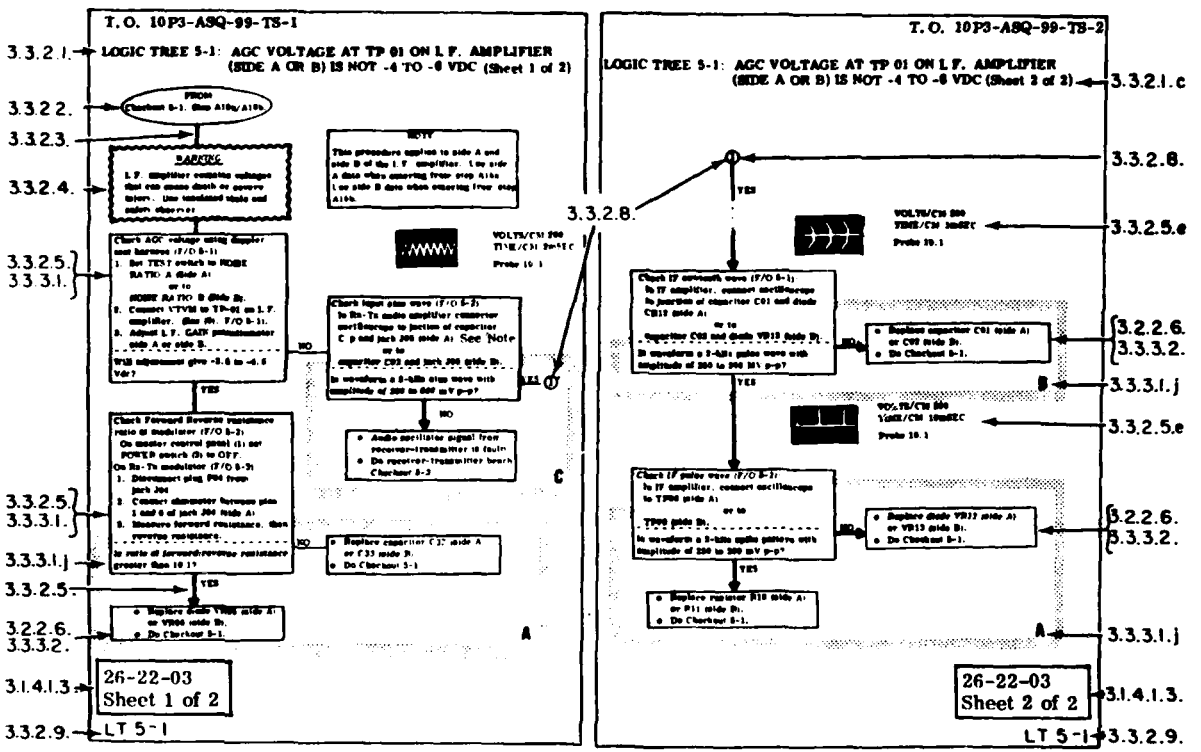
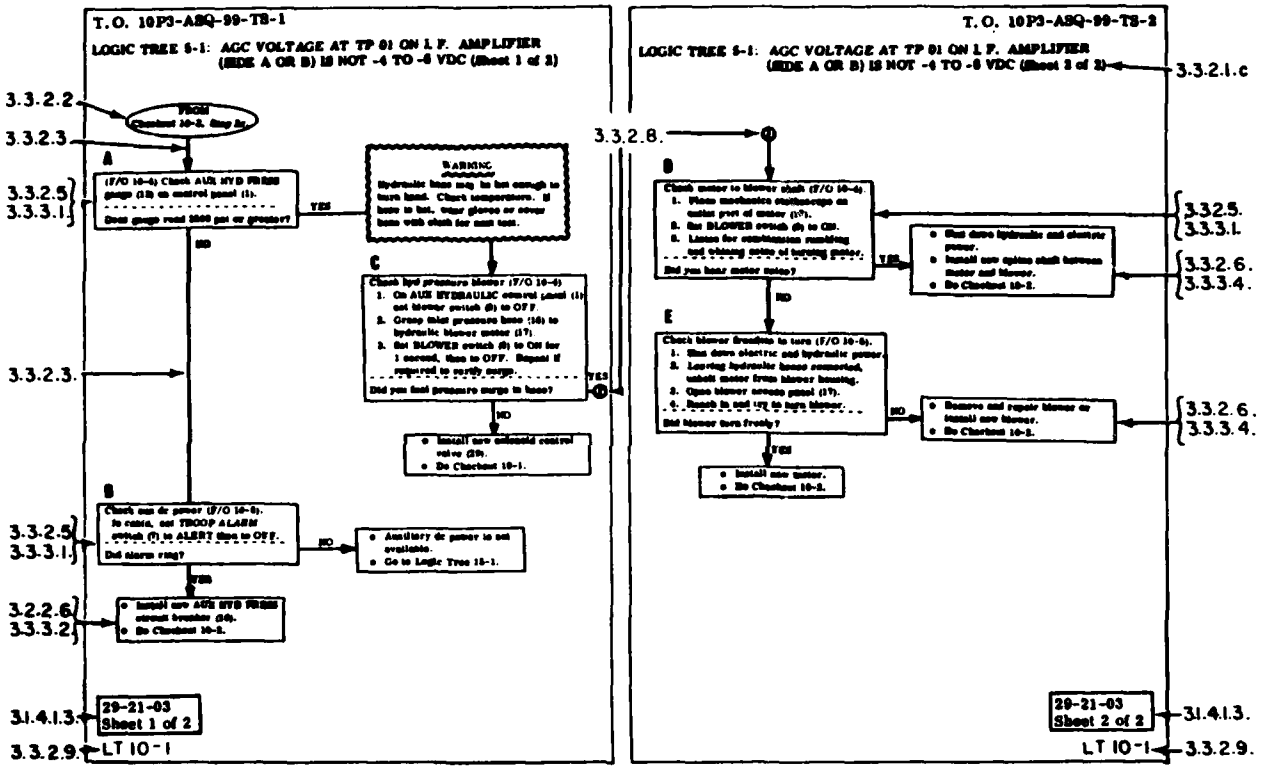


FIGURE 6. Sample layout for logic trees.



NOTE: SCREENED ENCLOSURES A, B, and C ARE FOR REFERENCE ONLY AND ARE NOT PART OF LOGIC TREE.

FIGURE 7. Sample logic tree for electronic system.



NOTE: A, B, C, D, and E MARKS ARE FOR REFERENCE ONLY AND ARE NOT PART OF LOGIC TREE.

FIGURE 8. Sample logic tree for electrohydraulic system

TABLE 6-1. Cabin services spot checks.

FAULT SYMPTOM	REF.	CORRECTIVE ACTION
1. No red lights on when LIGHTS switch (8) is set to NIGHT.	F/O 10-8	1. Close NIGHT LIGHTS and LIGHTS CONTROL circuit breakers (19) and (20).
2. Pressure door (5) will not open when handle rotated to OPEN.	F/O 10-15	2. Rotate handle to CLOSED. Set lock lever (7) to VENT for 30 seconds, then to UNLOCK.

TABLE 9-2. Communication system spot checks.

FAULT SYMPTOM	REF.	CORRECTIVE ACTION
1. Intercom system not energized when switches (8) thru (16) set to ON or INTERCOM.	F/O 9-20	1. Close INTERCOM, AUX AMP and MASTER circuit breakers (7), (8) and (10).
2. No feedback audio at CARGO MASTER panel (12).	F/O 9-22	2. Replace feedback amplifier (4).

FIGURE 9. Sample spot check tables.

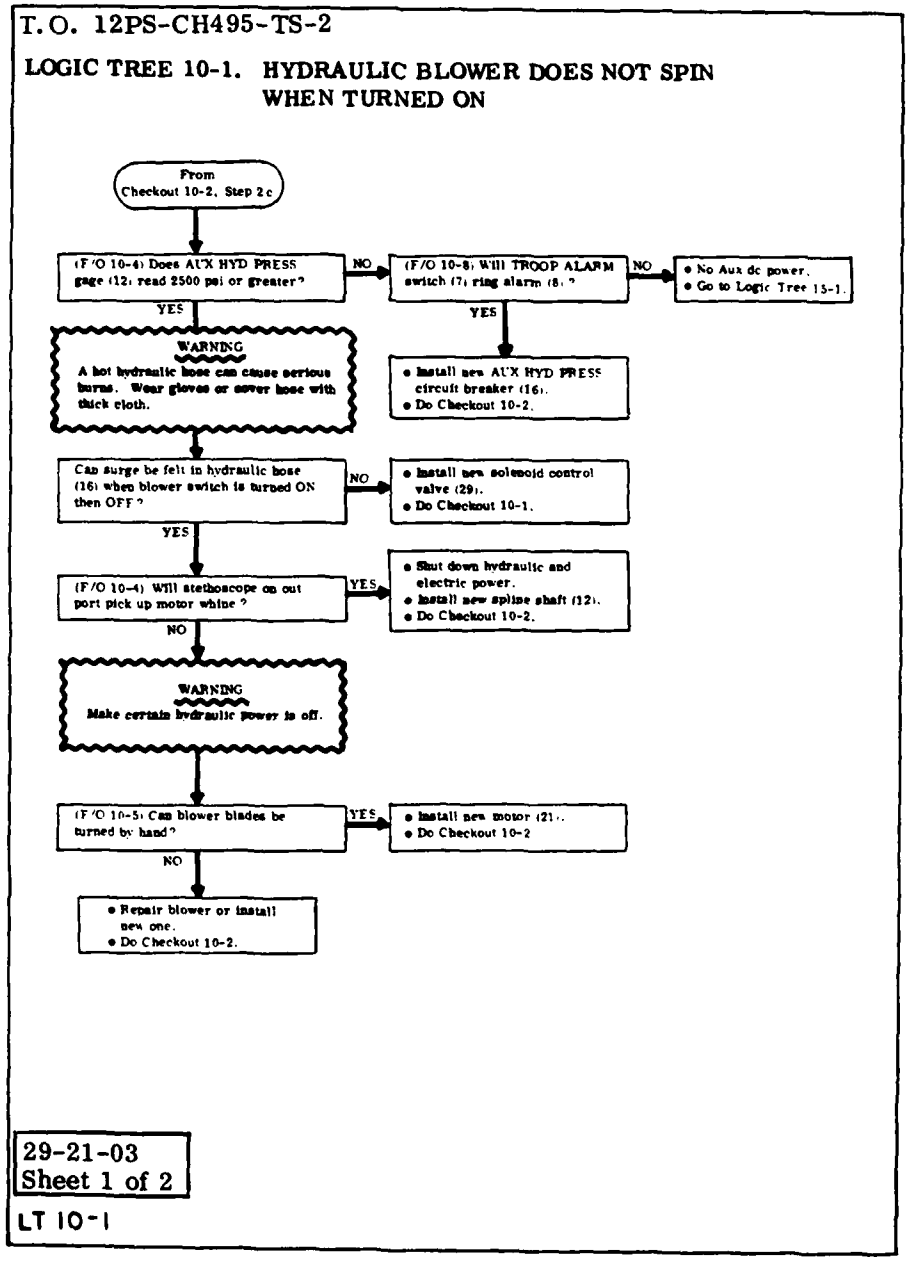


FIGURE 10. Sample logic tree with minimal enrichment.

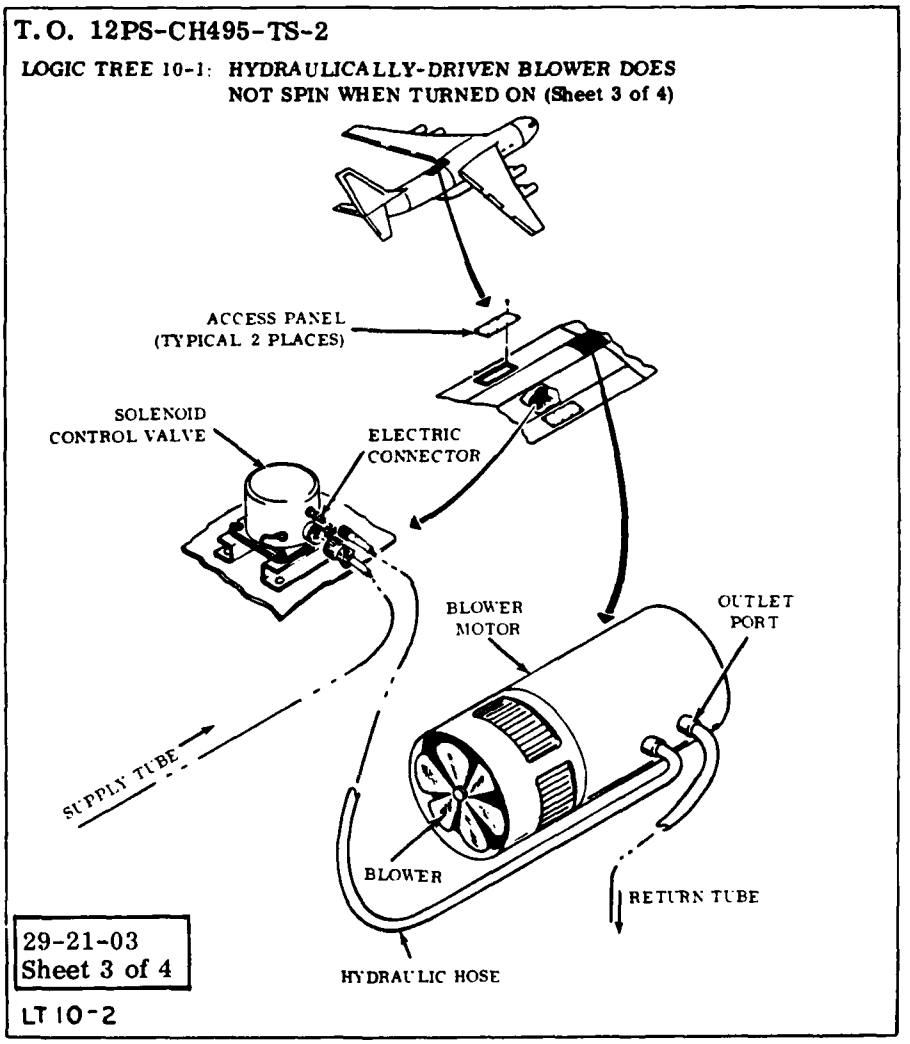


FIGURE 11. Sample logic tree with full enrichment (Sheet 1 of 2).

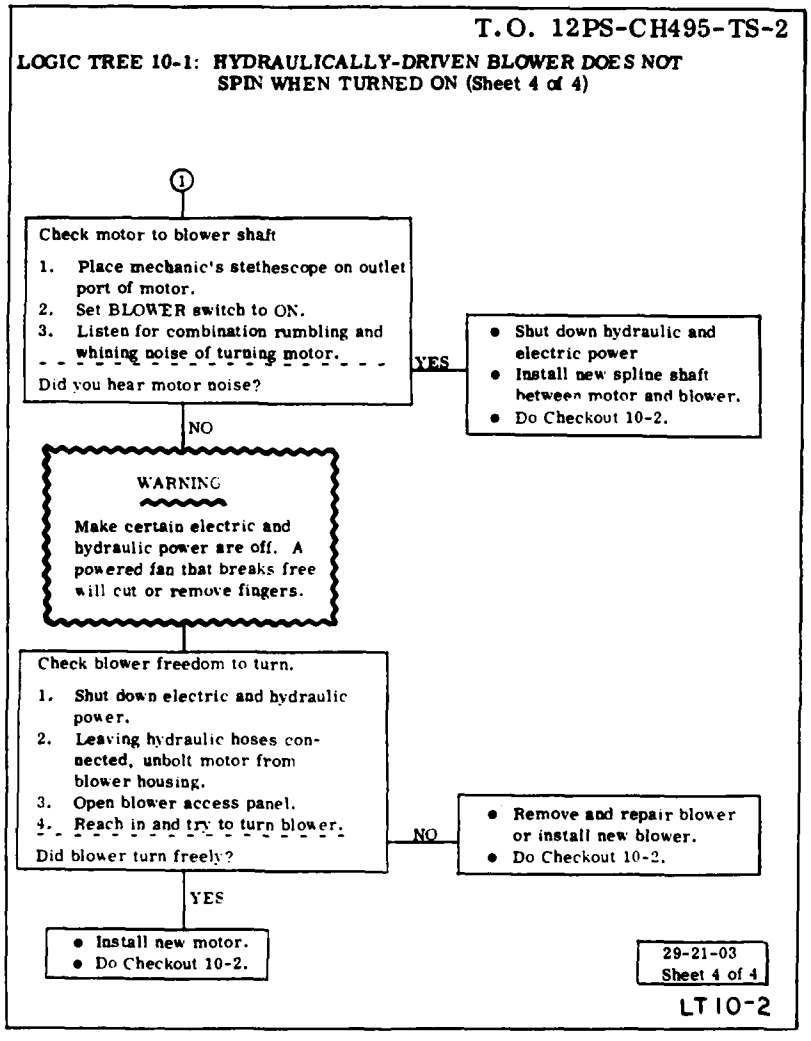
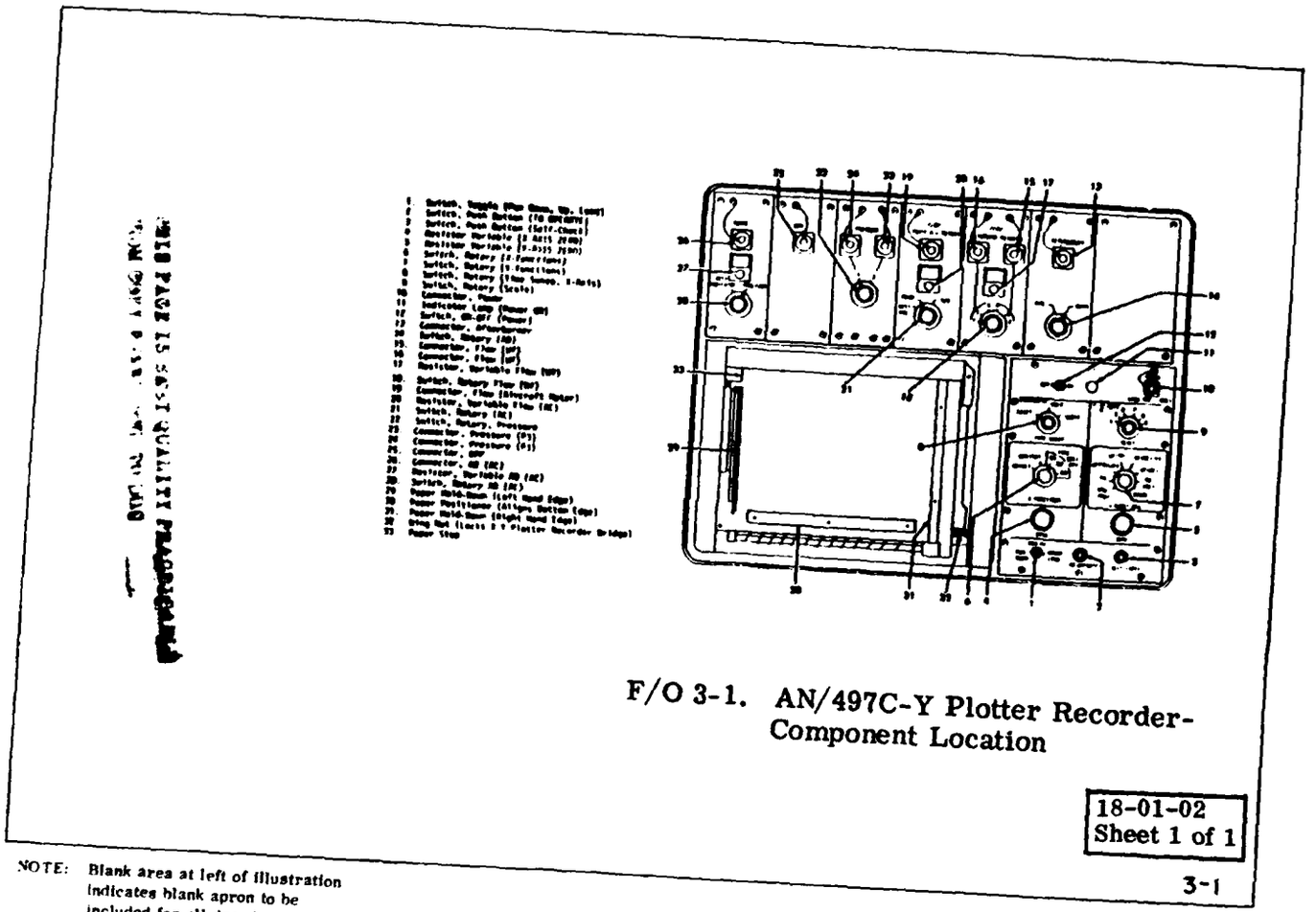


FIGURE 11. Sample logic tree with full enrichment (Sheet 2 of 2).



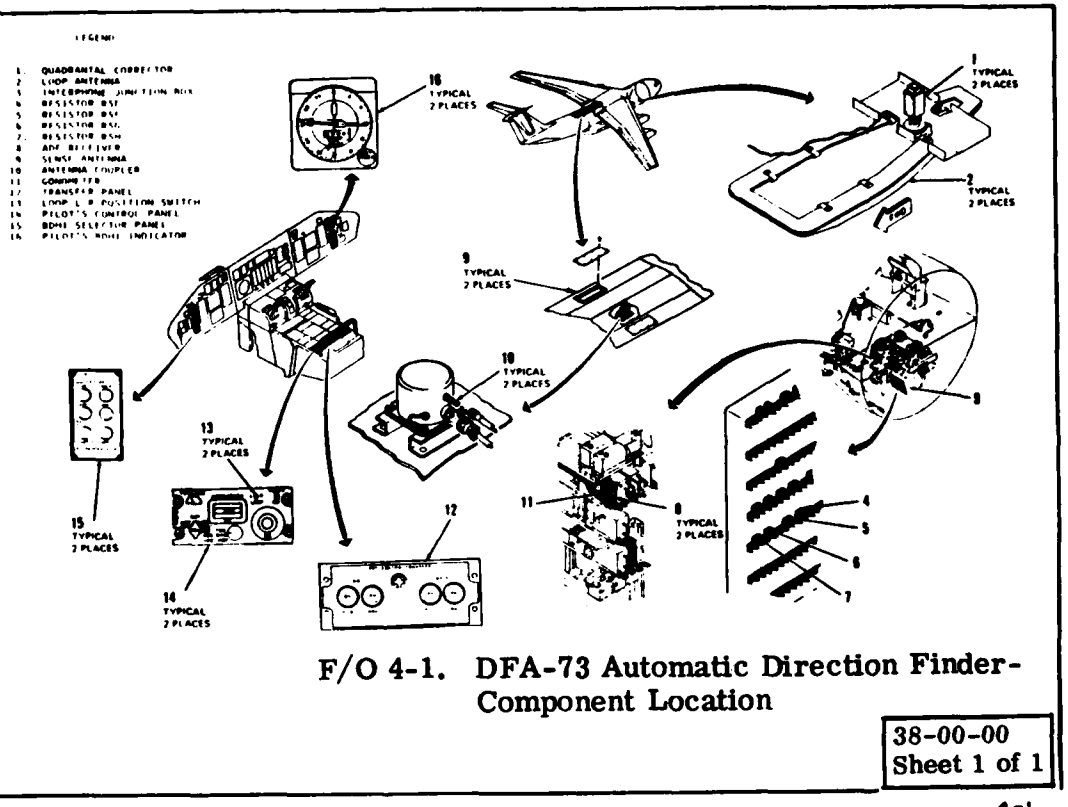
F/O 3-1. AN/497C-Y Plotter Recorder-Component Location

18-01-02
Sheet 1 of 1

3-1

NOTE: Blank area at left of illustration indicates blank apron to be included for all drawings.

FIGURE 12. Sample locator diagram (single-item).



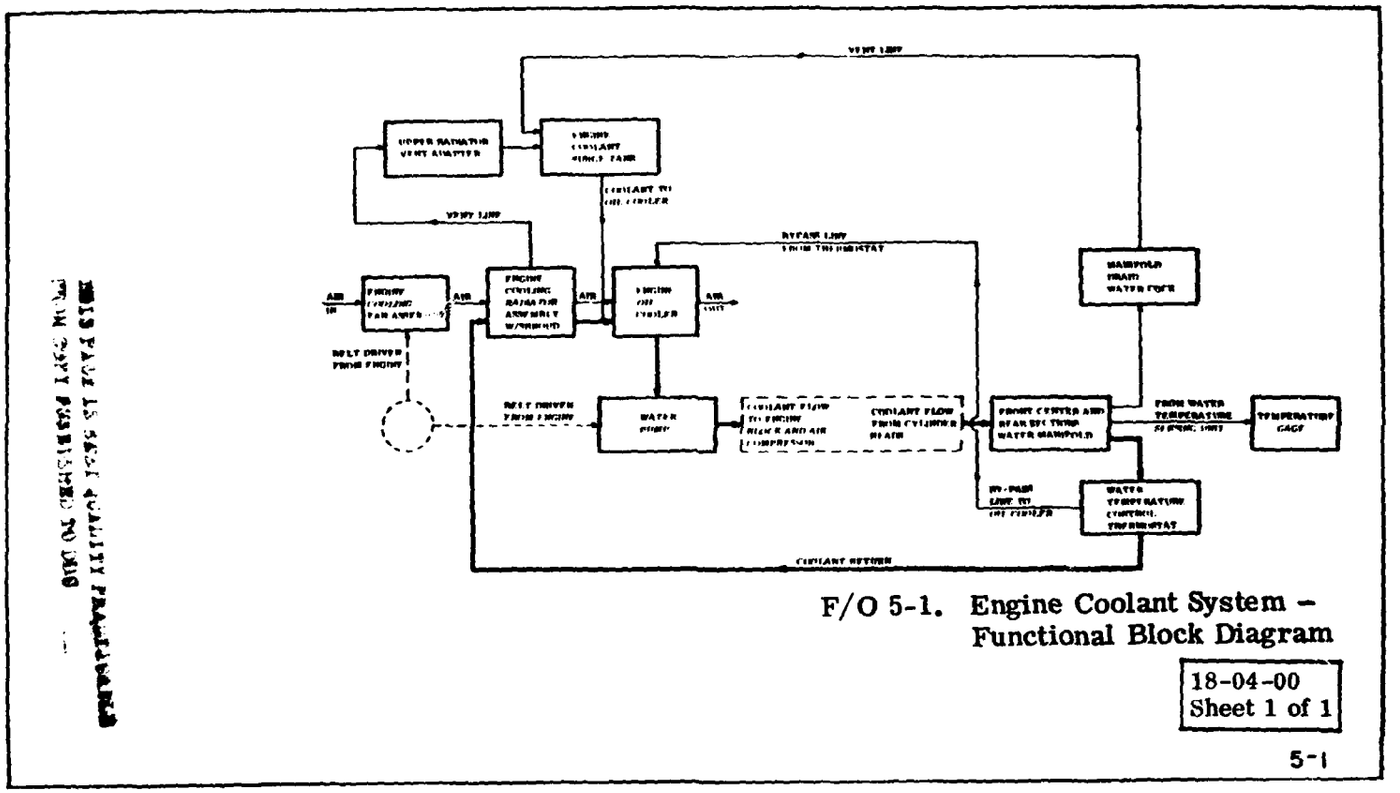
F/O 4-1. DFA-73 Automatic Direction Finder-Component Location

38-00-00
Sheet 1 of 1

4-1

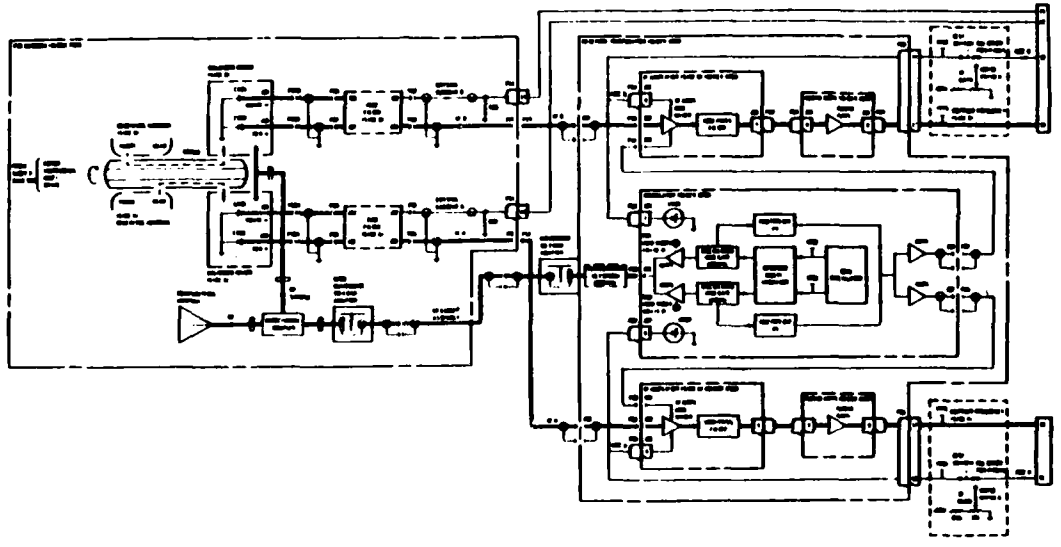
NOTE: Blank area at left of illustration indicates blank apron to be included for all drawings.

FIGURE 13. Sample locator diagram (multiple items).



NOTE: Blank area at left of illustration indicates blank apron to be included for all drawings.

FIGURE 14. Sample functional block diagram for mechanical system.



F/O 6-1. APX-999A Radar Set – Functional Block Diagram (Sheet 1 of 3)

12-05-06
Sheet 1 of 1

5-3

NOTE: Blank area at left of illustration indicates blank apron to be included for all drawings.

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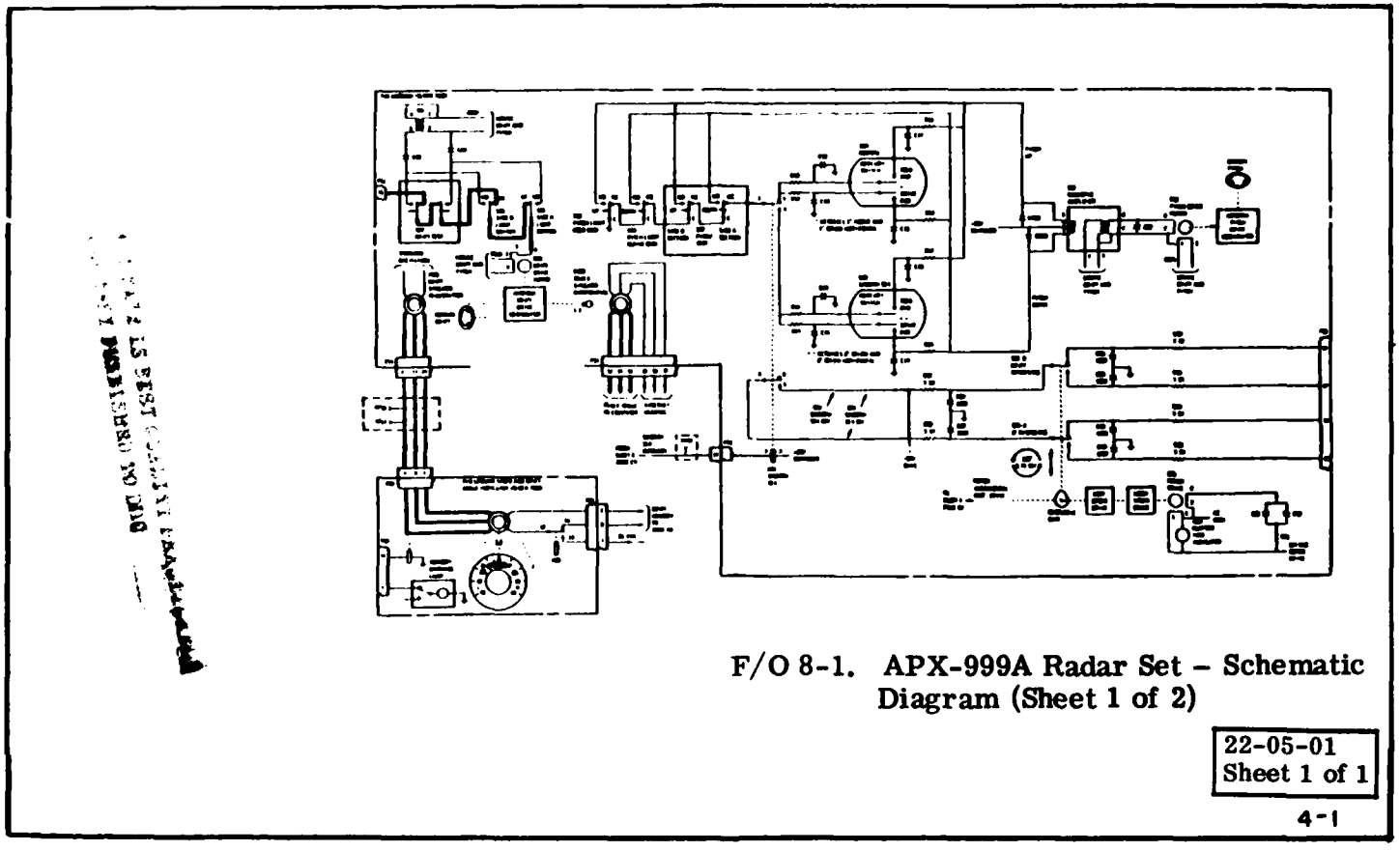
FIGURE 15. Sample functional block diagram for electronic system.



F/O 8-1. APX-999A Radar Set – Schematic Diagram (Sheet 1 of 2)

22-05-01
Sheet 1 of 1

4-1

NOTE: Blank area at left of illustration indicates blank apron to be included for all drawings.

FIGURE 16. Sample schematic diagram.

TABLE A-1. ASQ-000 radar set fault code cross index.

FAULT CODE	FAULT SYMPTOM	CHECKOUT & STEP NO.	LOGIC TREE	L.T. PAGE
2920/A1B1Z	Hydraulically Driven Blower Does Not Spin When Turned On	CO 10-2, 3c	10-1	LT 10-1

FIGURE 17. Sample fault code/LTTA cross index.

APPENDIX A

FAULT CODE/LTTA CROSS INDEX (ORGANIZATIONAL)

7. SCOPE

7.1 Purpose and description. This appendix defines requirements for an optional Organizational level Fault Code/LTTA Cross Index. The purpose of the index is to provide correlation between the LTTA manual furnished in accordance with this specification and the Fault Reporting and Fault Isolation manuals provided in accordance with MIL-M-83495. A Fault Code/LTTA Cross Index is a cross referencing list that matches Fault Codes from the Fault Reporting manual against corresponding Fault Symptoms, Logic Trees, and applicable Checkout steps in the LTTA manual. The specific uses of this cross index are to:

a. Use a Fault Code from the Fault Reporting manual for finding a corresponding Logic Gree in the LTTA manual.

b. Determine the Fault Code applicable to a Logic Tree.

c. Back reference a Fault Code and/or Logic Tree to the Checkout step at which the corresponding fault symptom was identified.

7.2 Detailed requirements. The requirements are as follows:

a. A Fault Code/LTTA Cross Index or Indexes shall be provided as an appendix to an Organizational LTTA when required by the contract Statement of Work. This requirement will normally be made only when a LTTA is to be prepared for a system for which there is, or will be, Fault Reporting and Fault Isolation manuals in accordance with MIL-M-83495.

b. A cross index shall be provided for each system or subsystem in each volume of an Organizational level LTTA. Such indexes shall be contained in an appendix under the title: FAULT CODE CROSS REFERENCE INDEX(ES).

c. Each index shall be prepared in accordance with the following format requirements:

(1) Each index shall be identified as a table by appendix number and sequence in the form: Table A-1, Table A-2, etc.

(2) Each table shall be titled by system or subsystem plus the words "Fault Code Cross Index."

(3) Each index shall provide data in five columns as demonstrated in Figure 17.

(4) The FAULT SYMPTOM column shall contain that part of the Logic Tree title which is a fault symptom (see 3.3.1).

(5) The FAULT CODE column shall contain the code that matches the Fault Symptom (see MIL-M-83495).

(6) The CHECKOUT & STEP NO. column shall show the number of the Checkout and the step within that Checkout at which the fault symptom was identified and which refers the troubleshooter to the Logic Tree listed in the adjoining column.

(7) The L. T. PAGE column shall show the page number for the corresponding Logic Tree.

APPENDIX B
VERB LIST

8. SCOPE

8.1 Purpose. Appendix B adds a verb list to this specification.

8.2 Applicable documents. There are no additional applicable documents.

8.3 Requirements. In the attached Verb List, each verb is defined in terms of one or more meanings associated with maintenance. A sample sentence has been provided for each usage. A number entry in the preference column indicates the standing of that verb compared to others with the same or similar meaning (highest ranking is 1). Any synonyms with which the verb was ranked are listed in terms of their own ranking. If a synonym holds first rank, it is underlined. Where necessary, special notes are also included. Lower ranking verbs can be used when the first ranked verb is particularly awkward or misleading in a given statement.

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Accomplish	To do, carry out or bring about; to reach an objective.	Accomplish a periodic inspection on the landing gear.	2	1. Perform 3. *Effect*	
Actuate	To put into mechanical motion or action; to move to action.	Actuate the handpump until the pressure gauge indicates 3000 psi.	-		
Adapt	To make fit a new situation or use, often by modifying.	Use the bushing to adapt the fuse to the projectile.	-		
Add	To put more in.	Add water to the battery.	-		
Adjust	1. To bring to a specified position or state. 2. To bring to a more satisfactory state; to manipulate controls, levers, linkages, etc.; to return equipment from an out-of-tolerance condition to an in-tolerance condition.	1. Adjust the micrometer to the given measurements. 2. Adjust cable tension using the turnbuckles.	-		
Advise	To give information or notice to.	Advise Person B that the brakes have been set.	4	1. Report to 2. Inform 3. Notify 5. Tell	
Advance	To move forward; to move ahead.	Advance the throttle	-		
Agitate	To move with a jerky, quick, or violent action.	Agitate the container so that the paint will be well mixed.	2	1. Shake	
Aid	To give help or support to; to assist.	Aid Person B to lift the load.	3	1. Assist 2. Help	
Alert	To warn; to call to a state of readiness or watchfulness; to notify (a Person) of an impending action.	Alert personnel that area will be cleared.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Align	To bring into line, to line up; to bring into precise adjustment, correct relative position or coincidence.	Align slot in turnbuckle barrel with slot in cable terminal. Align receiver IF strip.	-		
Allocate	To apportion for a specific purpose or to particular persons or things.	Allocate the various maintenance tasks to technicians.	3	1. Assign 2. Distribute	
Allow	1. To permit, to give opportunity to.	1. Allow the sediment to settle out.	1	2. Let	
	2. To allot or provide for.	2. Allow a 2-inch slack in the rope.	1	2. Leave	
Alternate	To perform or cause to occur by turns or in succession.	Alternate between pilot's and copilot's instrument test.	-		
Analysis	To examine and interpret test or inspection results to determine system or equipment condition or capabilities.	Analyze engine inspection findings to determine need for repairs.	-		
Apply	1. To lay or spread on.	1. Apply sealant to gap between the windshield and the aircraft structure.	1	2. Put	Use "lubricate" rather than "apply lubricant."
	2. To energize	2. a. Apply power or load. b. Apply pressure to cylinder.	-		
Arrange	To group according to quality, value, or other characteristics; to put in proper order.	Arrange components by size from smallest to largest.	1	2. Order	
Ascertain	To find out with certainty that a proper condition exists.	Ascertain that the light is off.	5	1. Be sure 2. Verify 3. Check 4. Determine	
Assemble	To fit and secure together the several parts of; to make or form by combining parts.	Assemble a jet engine in accordance with specified procedures.	1	2. Construct	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Assess	To determine the importance, size or value of; to evaluate.	Assess the success of the maintenance action.	2	1. Evaluate	
Assign	To apportion to for a specific purpose or to particular persons or things; to appoint to a duty.	Assign the various maintenance tasks to technicians.	1	2. Distribute 3. Allocate	
Assist	To give support or help; to aid.	Assist Person B to lift the antenna.	1	2. Help 3. Aid	
Assure	To make someone sure or certain; to inform positively.	Assure other technicians that all warning lights are off.	1		
Attach	To join or fasten to.	Attach electrical leads to the multimeter.	2	1. Connect 3. Mate 4. Join	Use "tag" in preference to "attach" a tag.
Back off	To cause to go in reverse or backward.	Back off nut to the nearest castellation.	-		
Balance	To equalize in weight, height, number, or proportion.	Balance aircraft so that it is stable.			
Be sure	To confirm that a proper condition exists; to find out with certainty.	Be sure that the light is off.	1	2. Verify 3. Check 4. Determine 5. Ascertain	
Be careful	To exercise caution; to take care.	Be careful not to inhale the fumes of the solvent.	-		
Bend	To turn or force from straight or even to curved or angular; or to force back to an original straight or even position.	Bend wire until it lays flat against the turnbuckle wall.	-		
Bleed	To extract or let out some or all of a contained substance from.	Bleed off tank air pressure.	-		
Blow	To send forth air, particularly from the lungs through the mouth.	Check for obstructions by disconnecting the hose at the air inlet and blowing through it.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Break	1. To separate into parts with suddenness or violence.	1. Never break safety wire to release air pressure.	-		
	2. To pull away.	2. Break the bead of the tire.	-		
Buck	To reseat or tighten rivets from the shank side.	Buck rivets to stop the leak.	-		
Calculate	To determine by arithmetic processes.	Calculate the voltage in a circuit with 10 amp of current and 5 ohms of resistance.	1	2. Figure 3. Compute	
Calibrate	To determine accuracy, deviation, or variation by special measurement or by comparison with a standard.	Calibrate torque handles at least once each month so that the accuracy can be depended upon.	-		
Cap	To provide with a covering; to install or provide with a device for closing off the end of a tube which has a male fitting.	Cap all lines which have exposed male fittings.	1	2. Install caps	
Care for	To take responsibility for the proper handling and upkeep of.	A mechanic cares for his tools.	-		
Catch	To prevent from falling to the ground; to capture.	Catch any fluid drippings in a drip pan.	-		
Categories	To put into categories or general classes.	Categorize components by their function.	2	1. Classify	For determining the classification of a supply item, use "identify."
Center	1. To adjust so that axes coincide.	1. Center the nose wheel of the aircraft.	-		
	2. To place in the middle of.	2. Center the pointer on the dial.	-		
Change	To replace with another comparable item; to substitute serviceable equipment for malfunctioning, worn out, or damaged equipment.	Change the switch contact points.	2	1. Replace	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Channel	To form, cut, or wear a groove in.	Channel the rods so that they can be inserted easily.	-		
Charge	To restore the active materials in a storage battery by the passage of a direct current through, in the opposite direction to that of the discharge.	Charge the battery for a short time before making a specific gravity check.	1	2. Cycle	
Check	1. To confirm or establish that that a proper condition exists; to ascertain that a given operation produces a specified result; to examine for satisfactory accuracy, safety, or performance; to confirm or determine measurements by use of visual or mechanical means.	1. Check that the light is off.	3	1. Be sure 2. Verify 4. Determine 5. Ascertain	
	2. To perform a critical visual observation or check for specific conditions; to test the condition of.	2. Check the components for wear, deterioration, or defects.	3	1. Inspect 2. Examine	
Check out	To perform specified operations to verify operational readiness of a subcomponent, component, subsystem, or system.	Check out the landing gear.	1	2. Test	
Chock	To place a blocking device, designated by the Air Force as a chock, adjacent to, in front of, and behind, to keep from moving.	Chock main and nose landing gear wheels.	-		
Choke	To enrich the fuel mixture of a motor by partially shutting off the air intake of the carburetor.	Choke engine as required to start.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Clamp	To fasten or press two or more parts together so as to hold them firmly.	Clamp the tensiometer to the cable by releasing the handle slowly.	-		
Classify	To put into categories or general classes.	Classify components by their function.	1	2. Categorize	For determining the classification of a supply item, use "identify".
Clean	To wash, scrub, or apply solvents to; remove dirt, corrosion, or grease.	Clean petroleum products from oxygen equipment.	-		
Clear	1. To move people and/or objects away from.	1. Clear the area.	-		
	2. To open the throttle of an idling engine to free it from carbon.	2. Clear the engine.	-		
Close	1. To block against entry or passage; to turn, push, or pull in the direction in which flow is impeded.	1. a. Close the valve. b. Close the access panel.	-		
	2. To set a circuit breaker into the position allowing current to flow through.	2. Close the circuit breaker.	-		
Coat	To cover or spread with a finishing, protecting layer.	Coat battery cables with grease.	-		
Code	To put into the form or symbols of a system used to represent words; to mark with identifying symbols.	Color code equipment parts.	-		
Collect	To bring together into one body or place; to accumulate.	Collect the required handtools.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Communicate	1. To exchange *information*.	1. Communicate with Person B during the entire procedure.	-		
	2. To make known.	2. Communicate to Person B that the brakes have been set.	5	1. Report to 2. Inform 3. Notify 4. Advise	
Compare	To examine the character or qualities of two or more items to discover resemblances of differences.	Compare the readings from protractor and template.	-		
Compile	To compose or put together out of materials from several sources.	Compile the records of all maintenance on the specified aircraft.	-		
Comply	To conform with directions or rules; to accept as authority; to obey.	Comply with directions.	2	1. Follow	
Compute	To determine by arithmetic processes.	Compute the voltage in a circuit with 10 amps of current and 5 ohms of resistance.	3	1. Calculate 2. Figure	
Condition	To put into a proper state for work or use.	Condition components before installing them.	-		
Conduct	To lead, manage, or direct.	Conduct the class in proper servicing procedures.	-		
Confer	To consult; to exchange views.	Confer with maintenance supervisor if necessary.	-		
Connect	1. To bring or fit together so as to form a unit, to couple keyed or matched equipment items.	1. Connect the antenna cable to the radio transmitter.	1	2. Attach 3. Mate 4. Joint	
	2. To attach or mate (an electrical device) to a service outlet.	2. a. Connect the soldering iron to the service power outlet. b. Connect VOM leads to test jacks.	2	1. Plug in	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Consolidate	To join together into one whole; to form into a compact mass.	Consolidate contents of both containers.	-		
Construct	To make or form by combining parts; to fit and secure together the several parts of.	Construct a jet engine in accordance with specified procedures.	2	1. Assemble	
Control	To exercise restraining or directing influence over, to fix or adjust the time, mount or rate of.	Control electrical current generation and distribution.	2	1. Regulate	
Coordinate	To bring into a common action, *movement or condition.*	Coordinate the activities of *Person B and Person C.*	-		
Copy	To make an imitation transcription, or reproduction of.	Copy the tail number on the record form.	-		
Correct	To make or set right; to alter or adjust so as to bring to some standard or required condition.	Correct any error before proceeding with activity.	-		
Cover	To protect or shelter by placing something over or around.	Cover tires whenever maintenance is done on the aircraft.	-		
Crack	To open slightly (the throttle) of an aircraft engine preparatory to starting the engine.	Crack and lock the throttle to 1/8 open.	-		
Crimp	To compress or deform a connection barrel around a cable to make an electrical connection.	Crimp a connector on the yellow wire.	-		
Cut	*To divide into parts using a* sharp instrument such as scissors or a knife.	*If the prongs of the cotter pin* are too long, they should be cut to proper length.	-		
Cycle	To charge (a battery) for a short time.	Cycle the battery before making the specific gravity check.	2	1. Charge for a short time.	
Deflate	To release air or gas from.	Deflate the shock strut to check fluid level.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Deflect	To move aircraft control surfaces (elevators, ailerons, etc.) to a position different from the major axes of the aircraft.	Deflect the surface upward to the mechanical stops.	-		
Deplete	To lessen markedly in quantity, content or power.	Deplete system pressure.	-		
Depress	To press or push down.	a. Depress both brake pedals. b. Depress pushbutton switch and then release.	-		
Depressurize	To release gas or fluid pressure from.	Depressurize the hydraulic system.	-		
Destroy	To ruin, demolish, or put out of existence; to make unfit for further use.	Destroy used hydraulic fluid containers.	-		
Detect	To discover or determine the existence, presence, or fact of.	Watch very carefully so as to detect any needle movement.	-		
Determine	1. To obtain definite and first-hand knowledge of; to confirm or establish that a proper condition exists.	1. Determine that the light is off.	4	1. Be sure 2. Verify 3. Check 5. Ascertain	
	2. To investigate and decide to discover by study or experiment.	2. Determine the amount of tension on a cable by following specified procedures.	1	2. Find	
Develop	To set forth or make clear by degrees or in detail.	Develop procedures fully.	-		
Device	To form by new combinations or applications of ideas or principles; to invent.	Devise new methods of troubleshooting the system.	-		
Diagnose	To recognize and identify the cause or nature of a condition, situation, or problem by examination or analysis.	Diagnose the malfunction.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Disassemble	To take to pieces; to take apart to the level of the next smaller unit or down to all removable parts.	Disassemble the No. 1 engine.	1	2. Dismantle	
Dismantle	To take to pieces; to take apart to the level of the next smaller unit or down to all removable parts.	Dismantle the No. 1 engine.	2	1. Disassemble	
Disconnect	1. To sever the connection between; to separate keyed or matched equipment parts.	1. Disconnect the bleed air hose from the leading edge anti-icing system.	-		
	2. To detach or separate (an electrical device) from a service outlet.	2. Disconnect the soldering iron from the service power outlet.	2	1. Unplug	
Disengage	To release or detach interlocking parts; to unfasten; to set free from an inactive or fixed position.	Disengage the parking brake.	2	1. Release 3. Unlock	For circuit breaker, use "open".
Dispatch	To send off or away with promptness or speed.	Dispatch report to supervising technician.	-		
Dispose of	To get rid of.	Dispose of unused hydraulic fluid left in the can.	-		
Distribute	1. The apportion for a specific purpose or to particular persons or things.	1. Distribute the various maintenance tasks to technicians.	2	1. Assign 3. Allocate	
	2. To divide among several or many; to divide or separate, especially into kinds.	2. Distribute paint for various sections of the aircraft.	-		
Drain	To draw off (liquid) gradually or completely.	Drain servicing hose after removing it from the filter valve.	-		
Draw in	To pull (liquid) up into a container through suction.	Fill hydrometer by drawing in electrolyte.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Dry	To cause to be free from water or liquid.	Dry bearings with low-pressure air.	-		
Effect	To do, carry out, or bring about; to reach an objective.	Effect a periodic inspection on the landing gear.	3	1. Perform 2. Accomplish	
Eliminate	To expel; to ignore or set aside as unimportant.	Eliminate all unnecessary movement.	-		
Employ	To put into action or service; to carry out a purpose or action by means of; to avail oneself of.	Employ only antimagnetic fasteners.	3	1. Use 2. Utilize	
Enforce	To compel or constrain.	Enforce safety regulations.	-		
Engage	To cause to interlock or mesh.	Engage threads of turnbuckle with threads of cable terminal.	-		For circuit breakers, use "close".
Enter	1. To go in or come in.	1. Enter the aircraft through the troop doors.	-		
	2. To put on record.	2. Enter the data on the form.			
Erase	A process to remove stored data from a storage medium such as a CRT display or magnetic tape.	Erase image from CRT screen.	-		
Erect	To put up by the fitting together.	Erect a special maintenance stand.	-		
Establish	To set on a firm basis.	Establish safety rules.	-		
Estimate	To judge or determine roughly the size, extent, or nature of.	Estimate amount of cleaning solvent which will be necessary.	-		
Evaluate	To determine the importance, size, or nature of; to appraise; to give a value or appraisal to on the basis of collected data.	Evaluate an operating engine.	1	2. Assess	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Examine	To perform a critical visual observation or check for specific conditions; to test the condition of.	Examine the component for wear, deterioration, or defects.	2	1. Inspect 3. Check	
Expedite	To accelerate the process or progress of.	Expedite the activity by assigning two men.	-		
Extend	To cause to be drawn out to fullest length.	Extend the main landing gear.	-		
Extract	To draw forth; to pull out forcibly.	Extract the cotter pin.	-		
Fabricate	To construct from standardized parts.	Fabricate rig pins from 0.25 in. rod.	-		
Figure	To determine by arithmetic processes.	Figure the voltage in a circuit with 10 amps of current and 5 ohms of resistance.	2	1. Calculate 3. Compute	
File	To rub smooth or cut away with a file (i.e., a tool with cutting ridges for forming or smoothing surfaces).	File one end of the rod to a point.	-		
Fill	To put into as much as can be held or conveniently contained or to a specified level.	Fill oil and de-icing tanks.	-		
Find	1. To discover or determine by search; to indicate the place, site, or limits of.	1. Find the No. 9 fitting.	2	1. Locate	
	2. To discover by study or experiment; to investigate and decide.	2. Find the amount of tension on a cable by following specified procedures.	2	1. Determine	
Flush	To pour liquid over or through; to wash out with a rush of liquid.	Drain and flush the hydraulic system if it is serviced with a wrong fluid.	-		
Fold	To lay one part over another part of; to reduce the length or bulk by doubling over.	Fold sides of curtain on creases.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF REFERENCE	NOTES
Follow	To accept as authority; to obey; to conform with directions or rules.	Follow directions.	1	2. Comply with	
Form	To give a particular shape to; to shape or mold into a certain state; to make up.	Form the compound so that it will fill the hole completely.	-		
Furnish	To supply what is needed, to equip.	Furnish a flashlight for Person B.	2	1. Provide	
Go to	To proceed to; to transport oneself to a given destination.	Go to the control pedestal and position switches appropriately.	-		
Ground	To connect a current, wire, or a piece of electrical equipment to a land or other specified surface.	Ground the servicing cart.	-		
Guard	To protect from danger; to defend.	Guard the area while maintenance is taking place.	-		
Guide	To manage or direct the movement of.	Guide the maintenance stand safely to its new position.	-		
Hand	To give, pass, or transmit with the hands.	Hand the refueling hose to the technician stationed on the wing.	-		
Handle	To manipulate (load, turn, raise, etc.) objects and equipment manually or with specially designated equipment, such as hoists.	Handle charger cylinders carefully.	-		
Hang	To fasten to some elevated point without support from below; to suspend.	Do not hang tools on projecting parts of the aircraft.	-		
Help	To give support, aid, or assistance to.	Help Person B lift the load.	2	1. Assist 3. Aid	
Hold	To have or keep in the grasp.	Hold the power switch in position until the voltmeter stabilizes.			

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Identify	1. To establish the identity of.	1. Identify components by name and function.	-		
	2. To determine the classification of a supply item.	2. Identify the component to be ordered from supply.	-		
Idle	To run an aircraft engine under reduced power without sufficient power being developed for movement of the aircraft.	Idle the engine for five minutes at 800 rpm.	-		
Immerse	To plunge into something that surrounds or covers, especially to plunge or dip into a fluid.	Immerse component in solvent.	-		
Improve	To make greater in amount or degree; to make better.	Improve procedures whenever feasible.	-		
Indicate	To point out.	Indicate which dial should be monitored.	-		
Inflate	To fill with a given amount of gas or air.	Inflate tire to desired pressure.	-		
Inform	To make known to; to give notice or report the occurrence of.	Inform Person B that the brakes have been set.	2	1. Report to 3. Notify 4. Advise 5. Tell	
Initiate	To perform actions necessary to set into operation, to set going, to begin.	Initiate operation of the powered AGE.	2	1. Start 3. Originate	
Inject	To throw, drive, or force in.	Inject lubricant into proper joint.	-		
Insert	To put or thrust in, into, or through.	Insert a wire through the hole in the turnbuckle.	1	2. Put	
Inspect	To perform a critical visual observation or check for specific conditions; to test the condition of.	Inspect the components for wear, deterioration or defects.	1	2. Examine 3. Check	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Install	1. To perform operations necessary to properly fit an equipment unit into the next larger assembly or system.	1. Install fuel manifold.			a. For wiring a circuit, use either "install wiring" or "wire".
	2. To place and attach.	2. Install nuts on bolts.			b. For safety wiring use either "safety wire" or "install safety wire".
					c. For screws, use "install screws" rather than "screw".
					d. Use "cap" "plug" rather than install caps (plugs).
Insure	To make certain, to ensure.	Insure that the area is clear of unnecessary personnel and equipment.	-		
Intercept	To stop or interrrupt the progress or course of.	Interrupt messages between flight station and tail section technicians.	-		
Interchange	To put each in the place of the other.	Interchange printed circuit cards A2 and A3.	-		
Interpret	To explain the meaning of.	Interpret instructions for inexperienced technicians.	-		
Investigate	To observe or study by close examination and systematic inquiry.	Investigate the cause of the breakdown.	-		
Isolate	To use test equipment to identify or select a source of trouble.	Isolate the source of the malfunction using pressure gauges.	-		
Jack	To use one or more jacks (i.e., mechanisms for exerting pressure to lift all or part of an aircraft).	Jack and level the aircraft in accordance with specified procedures.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Join	To bring or fit together so as form a unit; to couple keyed or matched equipment items.	Join the transmitter to the receiver with the power cable.	4	1. Connect 2. Attach 3. Mate	
Keep	To remain, to continue in a place.	Keep away from the danger area.	2	1. Stay	
Kick	To strike against with a foot.	Kick the wheel lightly if the strut binds.	-		
Latch	To catch with a device which holds a door when closed, even if not bolted.	Close and latch the aft petal doors.	-		
Leave	1. To go away from, depart.	1. Do not leave the area until this activity is complete.	-		
	2. To allot or provide for.	2. Leave a two-inch slack in the rope.	2	1. Allow	
Let	To permit; to give opportunity to.	Let the engine stabilize.	2	1. Allow	
Level	To cause an aircraft to become even or parallel with the plane of the horizon.	Jack and level the aircraft in accordance with specified procedure.	-		
Lift	To move or cause to be moved from a lower to a higher position; to elevate.	Lift the spoiler control lever to the ARMED position.	2	1. Raise	
Light	To cause to illuminate.	Light the field indicator light.	-		
Listen	To pay attention to sound.	Listen to the engine while it is operating.	-		
Load	To place in or on a means of conveyance; to place cargo or aircraft components on an airplane or other vehicle.	Load and secure aircraft components on specified truck.	-		

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VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Locate	1. To find, determine or indicate the place, site, or limits of.	1. Locate the No. 9 fitting.	1	2. Find	
	2. To set or establish in a particular spot, to station.	2. Locate the test equipment so that it can be seen by both technicians.	3-4	1. Position 2. Place 3-4. Set 5. Put	
Lock	To hold fast or inactive, to fix.	Lock the throttle after it has been properly set.	-		
Lock for	To visually search for.	Look for cracks, corrosion and damage during inspection of wheels and tires.	-		
Loop	To make into the form or shape of a loop (i.e., a fold or doubling of line leaving an aperture between the parts through which another line can be passed).	Loop the wire.	-		
Loosen	To release from restraint; to cause to become less tight fitting.	Loosen the locknut on the relief valve.	-		
Lower	To cause to move down; to depress as to direction.	Lower the exhaust stack into the stowed position.	-		
Lubricate	To put lubricant on specified locations.	Lubricate the wheel bearings.	1	2. Apply lubricant	
Maintain	1. To hold or keep in any particular state or condition, especially in a state of efficiency or validity.	1. An aircraft mechanic maintains aircraft.	-		
	2. To sustain or keep up.	2. Maintain standard forms on power plant operations.	-		
Make	To carry out or cause to occur.	Make corrections where necessary.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Mark	To label, to provide with an identifying or indicating symbol.	Mark each component before removing it.	-		If marking is to be done on a tag, use "tag".
Mate	To join or fit together; to couple.	Mate the proper transmitter and receiver.	3	1. Connect 2. Attach 4. Join	
Measure	To determine the dimensions, capacity, or amount by use of standard instruments or utensils.	a. Measure voltage drop across each unit of resistance. b. Measure input between TB-4 and ground.			
Mix	To combine or blend into one mass.	Never mix oxygen with other gases.	-		
Modify	To alter or change somewhat the form or qualities of.	A jet engine mechanic modifies turbofan engines.	-		
Monitor	1. To visually take note of; to pay attention to in order to check on action or change.	1. Monitor the indicator for changes in airspeed.	3	1. Observe 2. Watch	
	2. To continually or periodically attend to displays to determine equipment condition or operating status.	2. Monitor all engine instruments while starting the engines.	-		
Moor	To secure an aircraft to the ground by tying it down by ropes or cables.	Moor the aircraft when it is to be parked for an extended period of time.	-		
Mount	To attach to a support.	Mount the split-type wheel.	-		
Move	To change the location or position of.	Move and position a B-4 maintenance stand.	-		
Neutralize	To destroy the effectiveness of; to nullify; to make chemically neutral or electrically inert.	Neutralize the solution before applying it to aircraft surface.	-		
Notify	To make known to; to give notice or report the occurrence of.	Notify Person B that the brakes have been set.	3	1. Report to 2. Inform 4. Advise 5. Tell	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Observe	1. To conform one's actions of practice to.	1. Observe precautions.	-		
	2. To visually take note of; to pay attention to.	2. Observe the indicator for changes in airspeed.	1	2. Watch 3. Monitor	
Obtain	1. To get or find out by observation or special procedures.	1. Obtain a reading on the outside circle of the tensiometer.	2.	1. Take	
	2. To gain or attain.	2. Obtain the necessary supplies before starting on maintenance.			
Open	1. To move from closed position; to make available for passage by turning in an appropriate direction.	1. Open the valve.	-		
	2. To make available for entry or passage by turning back, removing, or clearing away.	2. Open the troop door.	-		
	3. To disengage or pull.	3. Open the appropriate circuit breakers.	-		
Operate	To control equipment in order to accomplish a specific purpose.	Operate crew stands and auxiliary power equipment.	-		
Order	1. To requisition or request from supply.	1. Order three cans of appropriate solvent.			
	2. To group according to quality, value, or other characteristics.	2. Order components by size from smallest to largest.	2.	1. Arrange	
Organize	To arrange elements into a whole of interdependent parts; to form into a coherent unity; to integrate.	Organize the activities of the assisting technicians.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Orient	1. To acquaint with the existing situation or environment.	1. Orient new techniques to location of shops and supplies.	-		
	2. To set or arrange in any determinate position.	2. Orient the aircraft away from wind direction.	-		
Originate	To give rise to, to set going, to begin.	Originate a new procedure.	3	1. Start 2. Initiate	
Overhaul	The act of disassembling equipment units down to all removable parts; cleaning; critically inspecting, repairing, restoring, and replacing where necessary; assembling, adjusting, aligning, recalibrating, and verifying operational readiness by test or Checkout; and packaging for transportation storage.	Overhaul the No. 2 engine.	-		
Pack	To fill completely with grease.	Pack the bearings.	-		
Paint	To apply color or pigment (suspended in suitable liquid) to the surface of.	Paint all exposed surfaces.	-		
Park	To bring (an aircraft) to a stop and leave it standing for atime, usually without pilot, in a specified area.	Park the aircraft between the yellow lines.	-		
Patch	To mend, cover, or fill up a hole or weak spot.	Patch the tubes where necessary.	-		
Perform	To do, carry out, or bring about; to reach an objective.	Perform a periodic inspection on the landing gear.	1	2. Accomplish 3. Effect	
Place	To put or set in a desired location or position.	Place the test equipment so that it can be seen by both technicians.	2	1. Position 3-4. Set 3-4. Locate 5. Put	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Plan	To devise or project the achievement of.	Plan the day's schedule for the technicians.	-		
Plug	To provide with a device for closing off and end of a tube which has a female fitting.	Plug all lines which have exposed female fittings.	1	2. Insert plugs 3. Install plugs	
Plug in	To attach or mate (an electrical device) to a service outlet.	Plug in the soldering iron at the service power outlet.	1	2. Connect	
Position	To put or set in given place, to locate.	Position the test equipment so that it can be seen by both technicians.	1	2. Place 3-4. Set 3-4. Locate 5. Put	
Post	To station at a given place.	Post one man in front of the aircraft.	-		
Prepare	To make ready; to arrange things in readiness.	Prepare the surface for paint.	-		
	To prepare or make ready for a maintenance activity.	Prepare the Trunion Shaft Kit for removal of the MLG shock strut.	1	2. Set up 3. Ready	
Prescribe	To lay down as a guide, direction, or rule of action; to specify with authority.	Prescribe repair activities to correct the malfunctions.	-		
Pre-set	To put in a desired position, adjustment, or condition beforehand.	Pre-set tension indicator dial to size of cable being checked.	-		
Press	To act upon through thrusting force exerted in contact.	Press the blower start button.	1	2. Push	For circuit breakers, use "close".
Pressurize	To apply pressure within by *filling with gas or liquid.*	Pressurize the booster hydraulic *system.*	-		
Prevent	To keep from happening or existing.	Prevent oil from spilling over on components.	-		

VERBS	DEFINITIONS	EXAMPLES	*PREF* RANK	*SYNONYMS BY ORDER* OF PREFERENCE	NOTES
Probe	To investigate thoroughly with a long, pointed device or by direct feeling.	Probe the tube with fingers.	-		
Process	To submit to a series of actions or operations leading to a particular end.	Process the forms so they will be compatible with new recording methods.	-		
Program	To work out a plan or procedure or a sequence of operations to be performed.	Program the maintenance activity in logical sequence.	-		
Provide	To supply what is needed; to equip.	Provide a flashlight for Person B.	1	2. Furnish	
Pull	To exert force upon an object so as to cause motion toward the force.	Pull out knob No. 6 on the oxygen servicing cart.	-		For circuit breakers, use "open".
Pump	1. Raise or lower by operating a device which raises, transfers, or compresses fluids by suction, pressure or both.	1. Pump up the ramp several inches.	-		
	2. To move up and down or in and out as if with a pump handle.	2. Pump engine primer knob.	-		
Puncture	To pierce with pointed instrument or object.	Be careful not to puncture tube while probing the inside of it.	-		
Purge	1. To free of sediment or trapped air by flushing or bleeding.	1. Purge fuel tanks.	-		
	2. To remove fuel or fuel vapors from engine by motoring engine with fuel switch off.	2. Purge engines.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANKS	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Push	1. To press against with force so as to cause motion away from the force.	1. Push the blower start button.	2	1. Press	For circuit breakers, use "close".
	2. To move away or ahead by steady pressure.	2. Push the servicing cart toward the aircraft.	-		
Put	1. To place in or through.	1. Put a wire through the hole hole in the turnbuckle.	2	1. Insert	
	2. To place or set in a desired position or location.	2. Put the test equipment where it can be seen by both technicians.	5	1. Position 2. Place 3-4. Set 3-4. Locate	
	3. To deposit or leave.	3. Put tools out on the bench.	-		Use "store" instead of "put away" for depositing or leaving in a specified place for future use.
	4. To lay or spread on or in.	4. Put sealant in the gap between the windshield and the aircraft structure.	1	1. Apply	
Quality	To declare competent or adequate.	Qualify components which check out successfully.			
Raise	To move or cause to be moved from a lower to a higher position, to elevate.	Raise the spoiler control lever to the ARMED position.	1	2. Lift	
Read	To interpret the meaning of by visual observation.	Read the ammeter.	-		
Readjust	To adjust again, to move back to a specified condition; to bring back to an in-tolerance condition.	Readjust the voltage after performing an operational check of the system.	-		
Ready	To prepare for a maintenance activity.	Ready for Trunnion Shaft Kit for removal of the MLG shock strut.	3	1. Set up 2. Prepare	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Reassemble	To refit and secure together the parts of after they have been taken apart.	Reassemble component before installation on aircraft.	-		
Recall	To call back.	Recall parts which have not been modified.	-		
Recap	To cap again; to replace a covering; to reinstall a fitting for closing the end of a tube.	Recap the filler valve.	-		
Recapitulate	To repeat briefly.	Recapitulate the task sequence.	-		Use "repeat briefly".
Receive	To comm into possession of; to get.	Receive supplies as they arrive.	-		
Recognize	To perceive to be something previously known or designated.	A jet engine mechanic recognizes troubles through evaluation of engine operational checks.	-		
Recommend	To urge the acceptance or use of.	Recommend procedure changes where appropriate.	-		
Recondition	To renew; to bring or put back into good condition.	Recondition the pilot's and copilot's seats.	1	2. Renovate	
Reconnect	To rejoin or refasten that which has been separated.	Reconnect aft pistons to forward pistons.	-		
Record	To set down in writing.	Record maintenance time on appropriate form.	-		
Reduce	To cause to be diminished in strength, density, or value.	Reduce pump flow.	-		
Refuel	To put fuel into the tanks of (as aircraft) again.	Refuel the system as outlined from applicable technical manuals.	-		
Regulate	To fix or adjust the time, amount or rate of; to exercise restraining or directing influence over.	Regulate electrical current generation and distribution.	1	2. Control	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Reinflate	To refill with a given amount of gas or air after deflation has occurred.	Reinflate tires to specified psi value.	-		
Reject	To refuse to have, use or take for some purpose.	Reject components which show excessive wear.	-		
Relay	To pass along by stages.	Relay the message to Person B.	-		
Reinstall	To perform operations necessary to properly refit an item that was previously removed into a system.	a. Reinstall covers. b. Reinstall interconnecting hose.	-		
Release	1. To set free from an inactive or fixed position; to unfasten or detach interlocking parts.	1. Release the parking brake.	1	2. Disengage 3. Unlock	
	2. To let go of.	2. Release tensiometer handle.	-		
	3. To set free from restraint or confinement.	3. Release pressure.	-		
Relieve	To ease or set free of a burden, to partially release.	Relieve hydraulic pressure before working on a system.	-		
Remove	1. To perform operations necessary to take an equipment unit out of the next larger assembly or system.	1. a. Remove bleed air shutoff valves. b. Remove bolts from nuts.	-		For screws, use "remove" rather than "unscrew".
	2. To take off or eliminate.	2. Remove paint.			
	3. To take or move away.	3. Remove covers.			
	4. To take off devices for closing off and end of a tube.	4. Remove caps (plugs) from all hydraulic lines.	1	2. Uncap (unplug)	
Renovate	To renew; to bring or put back into good condition.	Renovate the pilot's and copilot's seats.	2	1. Recondition	

VERBS	DEFINTIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Repair	To restore an equipment item to operable condition by a means other than total replacement of a part.	Repair connector by resoldering leads.	-		Repair includes such methods as gluing, reattaching, patching, welding, splinting, building up (a surface), sanding smooth, straightening, resoldering. Repair does not involve isolation of a fault. In accomplishing repair, no items are drawn from supply except consumables, attaching parts, or reinforcing parts.
Repeat	To make, do or perform again.	If keys do not engage lugs, remove wheel assembly and repeat procedure.	-		
Replace	To substitute serviceable equipment for malfunctioning, worn out, or damaged equipment.	Replace the switch contact	1	2. Change	
Replenish	To fill or build up again.	Replenish drinking water when supply runs low.	-		
Report	To describe as being in a specified state.	Report when ready.	1	2. Inform 3. Notify 4. Advise 5. Tell	
	To make known to; to give notice or report the occurrence of.	Report to Person B that the brakes have been set.			
Repressurize	To reapply pressure within by filling with gas or liquid after pressure has been released.	Repressurize the utility hydraulic system.	-		
Request	To ask for.	Request further information if necessary.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Reset	To put back into a desired position, adjustment or condition.	Reset the field after performing an operational check of the generator.	-		
Resolve	To clear up or find an answer to; to reach a decision about.	Resolve the inconsistency before proceeding with maintenance activity.	-		
Restore	To bring back or put back into a former or original state.	Restore hydraulic pressure.	-		
Retard	To manipulate so as to hold back or slow down; to hold back or slow down.	Retard the throttle.	-		
Retract	To draw up against or into the aircraft.	Retract the landing gear.	-		
Return	To bring, send, or put back to a former or proper place.	Return the horizontal stabilizer to the neutral position.	-		
Review	To examine again; to go over or examine critically or deliverately.	Review procedures which have not been performed for more than two months.	-		
Rework	To reprocess for further use; to revise.	Rework the report forms.	-		
Rig	To assemble, adjust, and align the major components of an aircraft (i.e., airfoils or other surfaces); to fit out (an aircraft) with control cables, bracing cables, pulleys, turnbuckles, etc.	Rig and adjust the mechanical linkage in the flight control system.	-		
Rinse	To cleanse (as from soap used in washing) by clear water.	Rinse the battery after cleaning it with soap water solution.	-		
Rope off	To partition, separate, or divide by a rope (i.e., a large stout cord of strands of fibers or wire twisted or braided together).	Clear and rope off an area around the aircraft and post warning signs.	-		

VERBS	DEFINTIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Rotate	To cause to revolve about an axis or center.	*Rotate the door handle counter* clockwise until catches retract.	1	2. Turn	
Route	To send by a selected course of travel; to divert in a specified direction.	Route the memo to all affected personnel.	-		
Rub	To move along the surface of a body with pressure.	Rub hands around connections.	-		
Safeguard	To provide a technical contrivance to prevent accident; to comply with precautionary measures or stipulation.	Safeguard technical manuals.	-		
Safety	1. To secure an aircraft part against loosening from *vibration.*	1. Safety the lock nut on the relief valve.			
	2. To use safety wire to make an aircraft component fast or safe or secure against loosening from vibration.	2. Safety the bolts with wire.	3	1. Safety wire 2. Secure (with wire) 4. Install (with wire)	
	3. To use a cotter pin to make an aircraft component fast or safe or secure against loosening from vibration.	3. Safety the bolt with acotter pin.	3	1. Secure 2. Install	
Safety wire	To use safety wire to make an aircraft component fast or safet or secure against loosening from vibration.	Safety wire the bolts.	1	2. Secure (with wire) 3. Safety 4. Install (with wire)	
Salvage	To rescue or save (as from discard, wreckage or ruin).	Salvage fuel which is drained from tanks.	-		
Scan	To make a wide, sweeping search of; to look through or over hastily.	Scan the flight engineer's panels before beginning maintenance activity.	-		
Schedule	To appoint, assign, or designate for a fixed future time; to make a timetable of.	Schedule maintenance activities for the day.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Screw	1. To attach, fasten, or close by means of a screw.	1. Screw the ram safety lock to the ram.	-		
	2. To attach by means of a twisting motion in the proper direction.	2. Screw in jack pad.	-		
	3. To attach screws by means of a twisting motion in the proper direction.	3. Screw in twelve screws around cover.	2	1. Install	
Scrub	To clean with hard rubbing.	Scrub all metal parts with a white powder deposit on them.	-		
Secure	1. To make fast or safe.	1. Load and secure components on trucks.	-		
	2. To safety (with safety wire or cotter pin) to make aircraft component fast or safe or to keep it from loosening during vibration.	2. a. Secure bolts with safety wire.	2	1. Safety wire 3. Safety 4. Install (with wire)	
		b. Secure the bolt with a cotter pin.	1	2. Install 3. Safety	
Select	To take by preference or fitness from a number or group, to pick out, to choose.	Select a battery cell and insert hydrometer nozzle in the cell.	-		
Service	To replenish consumable supplies, such as fuel, oil, filters, air, liquid oxygen, and related items.	Service each battery cell to only 3/8 inch above the plates.			Service is applicable when consumables are drained and filled. Service does not apply to scheduled lubrication or replenishment of consumables as part of another maintenance function.

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Set	1. To put a switch, pointer, or knob into a given position; to put equipment into a given adjustment, condition, or mode.	1. a. Set PWR switch to ON. b. Set the vehicle brakes.			
	2. To put or place in a desired orientation or location.	2. Set the test equipment so that it can be seen by both technicians.	3-4	1. Position 2. Place 3-4. Locate 5. Put	
Set up	To prepare or make ready for a maintenance activity.	Set up the Trunnion Shaft Kit for removal of the MLG shock strut.	2.	1. Prepare 3. Ready	
Shake	To move or cause to move to and fro in a quick, jerky manner.	Shake the container so that the paint will be well mixed.	-		
Shut down	To perform operations necessary to cause an equipment to cease or suspend operation.	Shut down the air conditioning.	1	2. Stop	
Signal	To notify or communicate by signals (i.e., a prearranged sign, notice or symbol conveying a command, warning, direction or other message).	Signal the pilot to move the aircraft to the left.	-		
Simulate	To give the appearance or effect of.	Simulate doppler radar signals.	-		
Slide	To cause to move in a smooth manner over a surface.	Slide the stand in close enough to do the work.	-		
Speak	To utter words or articulate sounds with the ordinary voice.	Speak the words one through ten into the microphone.	-		
Specify	To name or state explicitly or in detail.	Specify the manufacturer's number of the multimeter.	-		
Spill	To cause or allow to fall, flow or run out.	Be careful not to spill battery acid on clothing, hands.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Spin	To cause to revolve rapidly.	Spin wheel by hand until a bearing drag is noticed.	-		
Spray	To apply with a device which disperses a jet of finely divided liquid.	Spray the fuselage and tail sections moving from center to ends.	-		
Start	To perform actions necessary to set into operation, to set going, to begin.	Start the powered AGE.	1	2. Initiate 3. Originate	
Stay	To remain, to continue in a place.	Stay away from the danger area.	1	2. Keep	
Stimulate	To excite to activity or greater activity.	Stimulate flow by warming the lines.	-		
Stop	To perform actions necessary to cause an equipment to cease or suspend operation.	Stop the air conditioning.	2.	1. Shut down	
Store	To deposit or leave in a specified place for future use.	Store the wheel covers after maintenance activity is completed.	1	2. Stow 3. Put away	
Stow	To deposit or leave in a specified place for future use.	Stow the wheel covers after maintenance activity is completed.	2	1. Store 3. Put away	
Strike	To deliver or aim a blow or thrust; to hit.	Strike the designated spot with a hammer.	-		
Submit	To make available, to offer.	Submit request for modification *of procedures.*	-		
Suggest	To propose as desirable or fitting; to offer for consideration.	Suggest any changes which might be helpful.	-		
Superintend	To oversee; to have or exercise the charge of.	Superintend the repair of the the engines.	2	1. Supervise	
Supervise	To oversee; to have or exercise the charge of.	Supervise the repair of the engines.	1	2. Superintend	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Support	To hold up or provide a foundation or props for.	Support the elevator at both ends.	-		
Survey	To examine comprehensively as to condition, situation or value.	Survey entire aircraft surface.	-		
Synchronize	To cause to happen at the same time.	Synchronize the activities of Person A and Person B.	-		
Tabulate	To set up in the form of a table (with rows and columns); to compute by means of a table.	Tabulate maintenance times for each occurrence of the various maintenance activities.	-		
Tag	To provide with an identifying or indicating symbol with or as if with a tag (i.e., a cardboard, plastic or metal marker used for identification or classification); to label.	Tag each hydraulic line before removing it.	1	2. Attach a tag. 3. Mark 4. Connect a tag to	
Take	1. To get into or carry in one's hands or one's possession.	1. Take supplies out to the aircraft.	-		
	2. To get or find out by observation or special procedures.	2. Take a reading on the outside circle of the tensiometer.	1	2. Obtain	
Tap	To strike lightly.	Tap the eye of the cotter pin to seat it.	-		
Test	To perform specified operations to verify operational readiness of a component, subcomponent, system or subsystem.	Test the true airspeed indicator.	2	1. Checkout	
Throw	To move (a switch) so as to make or break a connection.	Throw switch to ON position.	-		Use "set" for all switches.
Tie	To fasten, attach or close by means of a line or cord.	Tie mooring ropes to tie points under wing and on nose.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Tighten	1. To perform necessary operations to fix more firmly in place.	1. Tighten all screws.	-		
	2. To apply a specified amount of force to produce a rotation or twisting motion to fix more firmly in place.	2. Tighten the nut to a torque value of 1000 in/lbs.	2	1. Torque	
Tilt	To cause to slope, lean or incline. incline.	Tilt maintenance stand backwards until wheels contact the ground.	-		
Torque	To apply a specified amount of force to produce a rotation or twisting motion to fix more firmly in place.	Torque the nut to 1000 in/lbs.	1	2. Tighten	Torque (noun) = length of wrench handle times applied force.
Tow	To pull along (an aircraft) by means of a towing vehicle and tow bar.	Tow aircraft to the washrack.	-		
Trace	To follow or study out in detail or step by step.	Visually trace the wiring diagram.	-		
Transfer	To convey or cause to pass from one place to another.	Transfer fuel and oil from one place to another.	-	2-3. Transport 2-3. Transmit	
Transmit	1. To convey or cause to pass from one place to another.	1. Transmit fuel and oil from one place to another.	2-3	1. Transfer 2-3. Transport	
	2. To send out a signal by radio waves or wires.	2. Transmit message to control tower.	-		
Transport	1. To convey or cause to pass from one place to another.	1. Transport fuel and oil from one tank to another.	2-3	1. Transfer 2-3. Transmit	
	2. To carry by hand or in a vehicle or hoist, or in a container, etc.	2. Transport landing gear to shop on dolly.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Trim	1. To free of excess or extraneous matter by or as if by cutting.	1. Trim patch to fit.	-		
	2. To adjust (a jet engine) to compensate for wear.	2. Trim the No. 1 engine.	-		
Troubleshoot	To localize and isolate the source of a malfunction or break down.	Troubleshoot the landing gear control circuit.	-		
Tune	To adjust for precise functioning.	Tune the transmitter for maximum output.	-		
Turn	To cause to revolve about an axis or center.	Turn the door handle counter clockwise until latches retract.	2	1. Rotate	
Turn off	To shut off or stop the flow of by or as if by moving a control to its OFF position.	Turn off power to the signal generator.	1		
Turn on	To cause to flow or operate by or as if by moving a control to its ON position.	Turn on power to the signal generator.	-		
Uncap	To remove a device for closing off the end of a tube with a male fitting.	Uncap and unplug all hydraulic lines.	2	1. Remove caps	
Unlock	To set free from an inactive or fixed position, to unfasten, to detach interlocking parts.	Unlock the parking brake.	3	1. Release 2. Disengage	
Unplug	1. To detach or separate (an electrical device) from a service outlet.	1. *Unplug the soldering iron.*	1.	2. Disconnect	
	2. To remove a device for closing off the end of a tube with female fittings.	2. Unplug and uncap all hydraulic lines.	2	1. Remove plugs	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Unscrew	1. To loosen or withdraw by turning in the proper direction.	1. Unscrew the jack pad.	-		
	2. To draw the screws from.	2. Unscrew twelve screws around cover.	2	1. Remove	
Unwind	To cause to uncoil or unroll.	Unwind hoses from hose rack.	-		
Use	To put into action or service; to avail oneself of; to carry out a purpose or action by means of.	Use only antimagnetic fasteners.	1	2. Utilize 3. Employ	
Utilize	To put into action or service; to avail oneself of; to carry out a purpose or action by means of.	Utilize only antimagnetic fasteners.	2	1. Use 3. Employ	
Verify	1. To confirm or establish that a proper condition exists.	1. Verify that the light is off.	2	1. Be sure 3. Check 4. Determine 5. Ascertain	
	2. To establish the truth or accuracy of.	2. Verify the readings before recording them.	-		
Wait	To suspend activity in a sequence of activities until a given condition occurs or a given time has elapsed.	Wait five minutes before performing the next task.	-		
Wash	To cleanse by or as if by the action of liquid; to remove (dirt) by rubbing or drenching with liquid.	Wash the battery with a cleaning solution and a stiff brush.	-		
Watch	To visually take note of, to pay attention to in order to check on action or change.	Watch the indicator for changes in airspeed.	2	1. Observe 3. Monitor	
Wire	To provide with wire, to use wire on.	Wire the circuit.	1	2. Install wiring	

VERBS	DEFINITIONS	EXAMPLES	PREF RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Withdraw	To take back, away, or out.	Withdraw the bar magnet from the center of the coil.			
Wrap	To wind, coil or twine as to encircle or cover something.	Wrap the wire around the terminal.	-		
Zero	The act of nulling a device or system.	Zero the meter with the leads disconnected.	-		

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